

THE
AMERICAN NATURALIST

VOL. XXXIV.

February, 1900.

No. 398.

THE ANGULATION OF THE LIMBS OF PRO-
BOSCIDIA, DINOCERATA, AND OTHER
QUADRUPEDS, IN ADAPTATION
TO WEIGHT.

HENRY FAIRFIELD OSBORN.

WITH material which in most cases belongs to several individuals the reconstruction of an extinct animal requires the greatest care and skill. When the proportions are determined the work is merely begun, for delicate calculation is needed to give the spine its proper curvature, to place the head in its true position, and then to give the bones of the fore and hind limbs their natural angles with each other. The angulation is most important because it finally determines the elevation of the body of the animal above the ground. Few of the mounted skeletons in our museums have the limbs correctly placed, and the drawings of skeletons, even in the best works, are often at fault in this respect.

Professor Marsh's statement in his monograph upon the Dinocerata, that in my restoration of *Loxolophodon* published in 1881, "the bones of the fore limb are in a position impossible in life," led me some years ago to study the means of

ascertaining the position and angulation of the limbs in fossil quadrupeds, and especially of the fore limb. Professor Marsh's criticism refers to the fact that, in the restoration referred to, the humerus is only slightly bent backwards, and this does not indicate sufficient flexure at the elbow.

In cases of this kind our material for study lies in the articular surfaces of the fossil limb bones and a comparison of these surfaces with those in the nearest allied living types. My ground for restoring the limbs of *Loxolophodon* was the close likeness which exists between the articular surfaces and shafts

of the humerus and radius and ulna of this type and those of the elephant.

In order to test the force of Professor Marsh's criticism and to guard

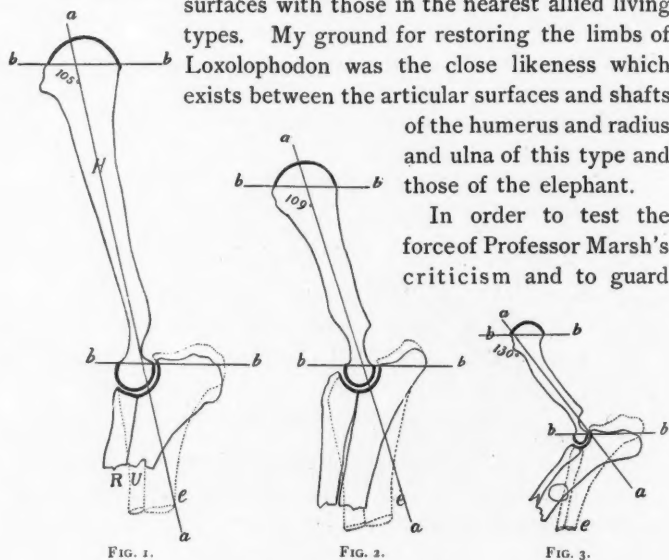


FIG. 1.

FIG. 2.

FIG. 3.

ANGULATION OF FORE LIMB.

FIG. 1. — *Elephas indicus*, longitudinal section of humerus, ulna and radius.

FIG. 2. — *Uintatherium cornutum*, longitudinal section of humerus, ulna and radius.

FIG. 3. — *Rhinoceros unicornis*, longitudinal section of humerus, ulna and radius.

against what might be a misleading resemblance, full-sized vertical sections were made of the fore limbs of *Uintatherium* (*Loxolophodon*) *cornutum* and of *Elephas indicus* in the Princeton collection. A section of a rhinoceros fore limb was also made for comparison. These were reduced by photography to a scale of 1 in 18 and are copied in Figs. 1, 2, and 3.

In each humerus a line (a-a) is drawn through the central axis of the shaft and two lines (b-b) are drawn through the

anterior and posterior intersecting edges of the proximal and distal articular surfaces or facets.

Several facts are at once brought out by these sections which bear upon the arthrology of the Ungulate limb.

(1) As the humerus, in the descent from the primitive bent-limbed types, is directly more vertically forwards, the articular facets are tilted from an oblique angle to more nearly a right angle with the shaft.

(2) At the same time the proximal or scapular facet shifts forwards, while the distal or ulno-radial facet shifts backwards



FIG. 4.—Mother elephant "Hebe" and baby "Americus," showing the excessive straightening or over extension of the fore limb. (By permission, from a copyrighted photograph by Schreiber & Sons, Philadelphia.)

upon the shaft's axis. An extreme instance of such shifting is shown in the transition from the rhinoceros (Fig. 3) to the elephant type (Fig. 1).

(3) The proximal and distal articular facets shift uniformly, and their edges are always found to be in nearly parallel planes, *b-b*, *b-b*.

In the straight-limbed Proboscidea and Dinocerata, by this means the proximal articular facets of the humerus come to lie almost directly upon the top of the shaft. In the Dinocerata the articular facets are slightly more inclined to the axis of the shaft than in the Proboscidea. The difference, however, is

only 4° , the elephant angle being 105° , while the *Loxolophodon* angle is 109° . This greater inclination is trifling when compared with the 130° of inclination seen in the rhinoceros, but it indicates that the humerus of *Uintatherium* was slightly more inclined and the elbow was slightly more bent than that of the elephant; the limb as a whole was therefore slightly more bent both in the standing position and in extreme extension.

The motions and positions of the elephant's limb, as shown by instantaneous photography, are very surprising. It is safe to say that the study of the skeleton alone would have given us a very faulty conception of this animal. The two most striking features are the great play of the wrist joint and the straight-

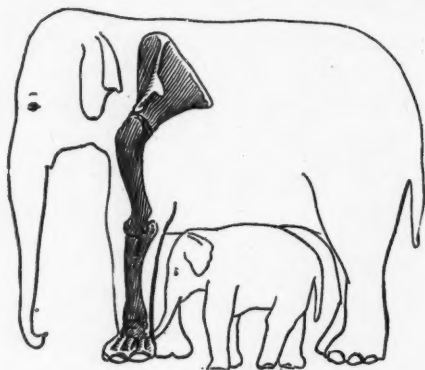


FIG. 5. — Diagram showing position of fore limb in "Hebe."

ness of the limbs. Fig. 5 is an accurate tracing of a photograph of "Hebe," in a standing position, taken by Schreiber & Sons, of Philadelphia. The skeleton fore limb, reduced to the same scale, is sketched in, with as much flexure at the elbow joint as a fair allowance for the enveloping muscles will permit. It shows that, in standing, the bones of the fore limb are in a nearly vertical line from the scapula downwards. The elbow joint is, in fact, much straighter in extreme extension than we should have inferred experimentally by fitting the bones of the arm and fore arm together.

The conclusion is that the motions and positions of the limbs in the ponderous representatives of the most highly

specialized Dinocerata were very similar to those of the modern elephants. The hind limb was as straight as in the elephant, and the fore limb in standing was a trifle more bent. A fore

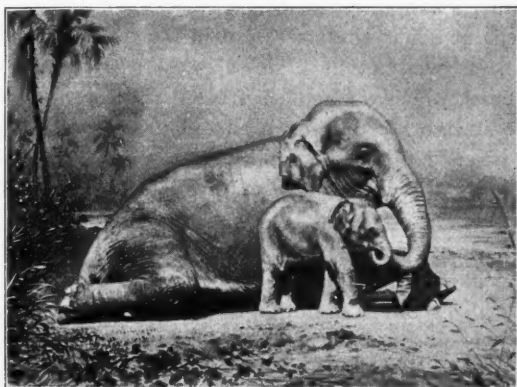


FIG. 6. — Same animal as in Fig. 4, showing sharp flexure at the wrist. (By permission, from a copyrighted photograph by Schreiber & Sons, Philadelphia.)

limb of *Uintatherium* in the Yale College collection gives evidence of considerable variation in this respect; some of the

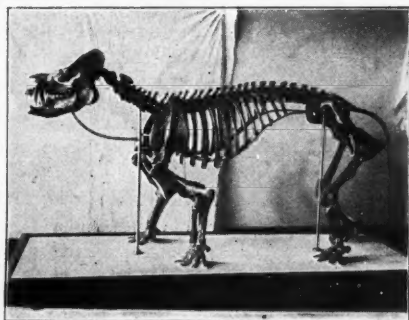


FIG. 7. — *Coryphodon testis*. Collection, American Museum of Natural History, showing marked primitive angulation of fore and hind limbs.

more primitive species, such as *Uintatherium mirabile*, were undoubtedly more straight limbed than others.

In the Coryphodontia of the lower Eocene, collateral ancestors of the Dinocerata, the angulation of the fore limbs is

almost as great as that in the rhinoceros. In the still earlier forms, such as *Pantolambda*, of the basal Eocene, the angulation is almost equal to that in the Creodonta, from which this entire order sprang.

There is no doubt, therefore, that in my restoration of *Loxolophodon*, as well as in Professor Cope's restoration of the same animal, which was published later, the fore limb is somewhat too straight. On the other hand, Professor Marsh seems to have given the limb too much flexure in his restoration of *Uintatherium* (*Tinoceras*) *ingens*, a slightly older type than *Loxolophodon*.

The more vertical position of the limb is secondary, it is observed, in all large quadrupeds. In the Titanotheres it has not proceeded so far as in the above types of mammals. Among reptiles it is observed in the heavy quadrupedal Sauropoda.

The straightening of the limb is an adaptation designed to transmit the increasing weight through a vertical shaft. Correlated with it are the shifting of the facets into the direct line of pressure and the alteration of their planes from an oblique to a right or horizontal angle with relation to the vertical shaft.

THE SPECIFIC GRAVITY OF SOME FRESH-
WATER ANIMALS IN RELATION TO
THEIR HABITS, DEVELOPMENT,
AND COMPOSITION.¹

STEPHEN R. WILLIAMS.

THE questions I have examined are: What is the specific gravity of animals living in water, and what bearing does their specific gravity have on their life histories?

These questions suggest the underlying problem of the specific gravity of protoplasms. I say protoplasms because two eggs, though very similar in appearance, existing under exactly the same conditions, may develop into two widely different animals.

The first part of my paper deals with the specific gravities of adult animals. The second part is a description of a number of series of growing tadpoles, in which I have ascertained, besides their specific gravity, their dry weight, and thus the percentage of water they contain. The third section of the paper has reference to the location of the water which, as shown by Davenport ('97-99, p. 285), is imbibed by the tadpole in its period of rapid growth.

I.

Protoplasm with its structure and functions very little specialized will be best found in simple, free-swimming water animals. An Amœba is apparently a body of simple protoplasm, and if a method delicate enough to find its specific gravity were devised, we should know very exactly how amœbic protoplasm compares in weight with its own volume of pure water, and how much effort would be necessary on the part of

¹ *Contributions from the Zoölogical Laboratory of the Museum of Comparative Zoölogy at Harvard College.* E. L. Mark, Director. No. 107.

the *Amœba* to maintain itself at a given level. I have, however, not been able to get the specific gravity of *Amœbæ*. But the larger soft-bodied animals, or animals with their shells removed, those with a small amount of foreign matter only, and especially embryos, offer favorable fields for the study of the specific gravity of protoplasms, and consequently I have made use of them.

Any information concerning the specific gravity of organisms will be of use in explaining motions, positions, and possible foods of the different animals. Tadpoles, found to be negatively geotactic by Miss Platt ('99), are forced to swim or to adhere by their suckers if they wish to remain above the bottom. The attitude of young tadpoles in an aquarium, as they hang tail downwards while clinging to the glass sides by their suckers, is due to the pull of gravity. Outdoors very few young tadpoles are seen at the surface of ponds where one knows they abound, though older stages are common at the surface. Stir up the bottom, and the surface for an instant will be black with tadpoles clinging to the bottom débris. An individual of a later stage whose intestine is filled with gas floats, can no longer feed on the bottom algæ, and is outstripped in growth by his normal fellows.

In determining specific gravity I have used the method suggested by Davenport ('97-99) and used by Miss Platt ('99), that of placing the animal in a solution of its own density. The density of this solution can be varied at will by the addition of known amounts of the dissolved substance or of water.

I found it necessary to stupefy all the free-swimming animals experimented upon. For this purpose I generally used chloroform as the most convenient reagent. It is, however, unsatisfactory for *Planaria*, as the irritation causes a slime to be secreted, which buoys up the animal greatly. It causes Protozoa to burst. For *Planarians* a solution of CO_2 gas in water is excellent. For *Stentors* and *Bursaria*, being unable to stupefy without killing, I tried four per cent formol, absolute alcohol, CO_2 , and chloroform, each without success. One-half per cent osmic acid and hot Perenyi's solution were fairly good, though most of the *Stentors* contracted to balls under the

influence of the reagents. Flemming's solution (weak) gave the best results. Many Stentors kept their extended shape and upon microscopic inspection appeared little altered.

I used gum arabic to regulate the density of my solutions, since, as suggested by Dr. Davenport, it is not injurious to animals immersed in it. It is more convenient to take a solution of high specific gravity and lower this gradually by adding water, than to increase the density by adding known weights of gum. Since different pieces of gum vary noticeably in density, two solutions made in exactly the same proportions may vary perceptibly in their buoyant effect. Consequently, to get a consistently acting medium which can be used throughout a series of experiments and which, each time it is made up, acts in about the same way, I made up a stock solution of 15 grams gum arabic and 30 cc. of distilled water. With a bit of camphor to keep out bacteria and a glass-stoppered vessel to prevent evaporation, there is no appreciable change in a month's time. A long pipette and a large test-tube, both marked in cubic centimeters on the outside, are the only apparatus necessary. The marking on the outside of the test-tube is absolutely essential to avoid uncertainty as to how many cubic centimeters have been added to the mixture.

In making a series of gum-arabic solutions I found that a gram of gum arabic when dissolved occupies between 0.66 and 0.72 cc. According to Landolt und Börnstein's Tabellen ('94), the specific gravity of the gums which are included under the name "gum arabic" varies between 1.31 and 1.45. The space that one gram occupies varies, then, between 0.763 and 0.689 cc. Comparing this with the observed volumes, I feel justified in assuming as an average the space value 0.7 cc. for one gram of dissolved gum arabic. On this basis the two tables which follow (p. 98) have been computed.

To make my stock solution I used 15 grams gum, which at 0.7 cc. space per gram occupies 10.5 cc. Adding 30 cc. of (distilled) water, the whole volume is 40.5 cc. The total weight is 45 grams, and weight divided by volume gives 1.111 + as the specific gravity of the mixture. The second number in the table is found by adding to 1 cc. of this mixture 1 cc. of pure

water and dividing the combined weight (2.111+) by the combined volume (2), which gives 1.056—. For the third place in the table I added to 1 cc. of the original mixture 2 cc. of pure water, 3.111 + divided by 3 giving 1.037, and so on.

TABLE I. — SPECIFIC GRAVITY OF SUCCESSIVE DILUTIONS OF GUM-ARABIC SOLUTION.

Starting with 1 cc. of the stock solution and adding water 1 cc. at a time, 1 gram gum arabic being reckoned as the equivalent of 0.7 cc. volume.

Vol. added	0	1	2	3	4	5	6	7	8	9
Sp. gr.	1.111+	1.056—	1.037	1.028	1.022	1.0185	1.016	1.014	1.012	1.011
Vol. added	10	11	12	13	14	15	16	17	18	19
Sp. gr.	1.010	1.009	1.0085	1.008	1.0074	1.007	1.0065	1.006	1.0058	1.0055
Vol. added	20	21	22	23	24	25	26	27	28	29
Sp. gr.	1.0053	1.005	1.0048	1.0046	1.0044	1.0042	1.0041	1.004	1.0038	1.0037
Vol. added	30	31	32	33	34	35	36	37	38	39
Sp. gr.	1.0036	1.0034	1.0033	1.0032	1.0031	1.003	1.003	1.003	1.0029	1.0028

TABLE II. — MODIFICATION FOR USE WITH MINUTE ANIMALS.

By starting with $\frac{1}{4}$ cc. of the stock solution and adding $\frac{1}{12}$ cc. of water at a time, there is a smaller interval between two steps than is possible by the method of Table I.

Vol. added	0	.33	.67	1	1.33	1.67	2	2.33	2.67	3
Sp. gr.	1.111	1.083	1.0667	1.056	1.047	1.041	1.037	1.033	1.030	1.028
Vol. added	3.33	3.67	4	4.33	4.67	5	5.33	5.67	6	6.33
Sp. gr.	1.025	1.024	1.022	1.021—	1.019+	1.018+	1.017	1.0165	1.016—	1.015
Vol. added	6.67	7	7.33							
Sp. gr.	1.0145	1.014	1.013							

I experimented with a Beaum 's hydrometer to test how nearly the calculated values of my table matched the observed values of the hydrometer reading. One experiment began with water giving a hydrometer reading of 1.003. After dissolving 5 grams of gum in 240 cc. of this water, the hydrometer reading was 1.011. Deducting the discrepancy of the reading for the water taken, the true specific gravity of the solution was 1.008. (The exact reading is difficult to be certain of, because of capillarity. I took the mean of a number of readings made by myself and by other persons reading independently.) By dividing the volume, 243.5 (counting one gram space as 0.7 cc., as in the tables), into the weight, 245, the specific gravity resulting is 1.006+. So the hydrometer read nearly 0.02 higher than the calculated specific gravity. In another test, to 238 cc. distilled water at slightly more than 1.000 sp. gr., 5 grams of gum were added, whereupon the hydrometer stood at 1.010. The calculated gravity is 1.0062+, a little less than 0.004 lower than the hydrometer reading. My results, then, are somewhat lower than the hydrometer would have made them. Taking into account the possible variation in the specific gravity of the gum, the two correspond quite closely.

To determine whether different parts of a gum solution were of the same density, I tested a single mixture: 254 cc. of a solution in which the hydrometer stood at 1.037 were divided into upper and lower halves as gently as possible. To each half was then added its own volume of pure water. Testing each, it was found that the lower half had a specific gravity of 1.020, while the upper read 1.018. As the solution had stood for some hours before being divided, I have assumed that the upper and lower halves of a solution were of the same density.

I have written above each sp. gr. value in the table the fraction of the starting amount (in case of Table II $\frac{1}{4}$ cc. of the gum-arabic mixture) which was added in the form of pure water. Taking, for example, the sixth place in Table II, the starting quantity of the mixture + 1.67 times its volume of water has a resulting specific gravity of 1.041.

In performing an experiment I put 1 cc. of the gum mixture into a test-tube with a long pipette, taking care not to draw

the gum above the 1 cc. mark and not to get any on the sides of the test-tube. Then I lifted the animals with as little water as possible into the solution. Where I knew that the specific gravity was less than 1.111, I took 1 cc. of water with them. Animals must be placed underneath the surface of the liquid, not dropped upon it, as some are buoyed up by the surface film, and so do not sink in solutions lighter than themselves. (Planaria and snails are thus supported in common pond water.) As it is very difficult to force out the gum adhering to the sides of the pipette, I made an allowance for the diminution of bore due to the adhering gum when adding the first cubic centimeter of pure water. By using this pipette to add the water, the gum mixture will soon be washed completely out into the test-tube, where it belongs.

The very heavy bodies — such as the eggs — and the very light ones — such as the older tadpoles (in general, the ends of the series) — afford the least accurate determinations of their specific gravity. To have a uniform standard for all, I assumed that in each case, after the addition of more water, an animal floated unless in sinking it touched the bottom or curving end of the test-tube.

I give my results in the form of a table (in which the animals are arranged according to their systematic relations) showing the number of specimens used, the average specific gravity, and the probable error. In the case of starred animals the solutions given by Table II were employed. This involved less rough treatment than by using the method of Table I.

There are five animals at the end of the table which were not tested in sufficient numbers to warrant comparison with the others.

All the free-swimming animals tested (excepting old tadpoles) tend, when quiescent, to be at the bottom and to rise must swim. That the lighter animals need less effort to swim is well illustrated by the two entomostracans, *Cypridopsis* and *Simocephalus*. *Simocephalus* moves without much effort and often very slowly in the water. *Cypridopsis*, on the other hand, must move rapidly and continuously or it sinks. It requires a distinct effort for a mosquito larva to get to the surface.

TABLE III.

ANIMAL.	NUMBER OF SPECIMENS.	AVERAGE SP. GR.	PROBABLE ERROR.
*Stentor cœruleus Ehrbg.	72	1.016+	.0016
*Bursaria (<i>sp.</i> ?)	66	1.0142	.00067
Hydra viridis L.	18	1.0095	.0013
Hydra { <i>fusca</i> L. } { or <i>grisea</i> L. }	6	1.0115	.0009
Cordylophora lacustris Allm.	5 heads	1.016	—
Planaria maculata Leidy	27	1.030	.0026
*Rotifer vulgaris Ehrbg.	15	1.021	—
Dero intermedia Cragin	36	1.022	.002
Cyclops albidus Jurine	16	1.0222	.0029
Simocephalus vetula Müller	17	1.0136	.0012
Cypridopsis vidua Müller	40	1.046	—
Culex (larvæ)	11	1.0185	.0002
Agriion larvæ	8	1.046	—
Aquatic fly larvæ (<i>sp.</i> ?)	Many	1.0185	—
Physa (shell removed)	4	1.037	—
Nephele (<i>sp.</i> ?)	1	1.037	—
Asellus	3	1.037	—

When there, the surface film holds up the breathing tube with its spreading hairs. Whenever that support is lost the animal sinks. A Cyclops, when moving slowly, can be seen to move upwards with a jerking motion, then to sink slightly, then to jerk again, and so on. To remain motionless it must have its antennæ on the surface film.

A sinking animal, like a lifeless body, always falls with the heavy end downward. Many animals do not give special evidence in this direction. Cyclops usually sinks head downward, the tail being at an angle of 45° with the horizon. Hydra, unless unusually dense near the mouth (for instance, with food in the gastrovascular cavity), sinks foot downward. One with a bud sank bud downward.

In the tadpole the center of gravity changes position in the course of development. Up to a length of about 6 mm., it is in the head region, for that always sinks first. In later stages the center of gravity moves backward nearly to the root of the

tail, and tadpoles hang in the water with the tail at least 20° lower than the head. Many of the older ones seem no heavier than water. As soon as tadpoles begin to depend on food taken into the alimentary canal from without, the canal may become filled with air or gas, so that the animal floats belly up. This condition is not permanent, for I have isolated such floating tadpoles and they regained the bottom in the course of a day. I have seen a tadpole force from its mouth as many as twelve bubbles of gas. After attaining the length of 10–11 mm., the specific gravity of the tadpole depends much on the condition of the animal and on the development of the lungs. The refuse of the food in the alimentary canal, which consists of partially digested green water plants and many diatoms, may aid the animal in sinking. It certainly helps move back the center of gravity of the animal from the head region toward the tail.

II.

I have found the specific gravity of four series of tadpoles—two in the spring of 1898 and two in the spring of 1899. In each instance one series was the young of *Rana silvatica*, the other those of *Bufo lentiginosus*.

TABLE IV.—SPECIFIC GRAVITY OF FROG AND TOAD TADPOLES.

LENGTH IN MM. =	ROUND EGGS.	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-16+
<i>Rana silvatica</i> , 1898	—	—	1.022	1.013	—	1.013	1.008	1.005	1.0055
<i>Rana silvatica</i> , 1899	—	1.111	1.11	1.050	1.042	1.028	—	1.010	1.0052
<i>Bufo lentiginosus</i> , 1898	1.038	1.037	1.037	—	1.022	1.013	1.013	1.010	—
<i>Bufo lentiginosus</i> , 1899	1.037	1.037	1.030	1.022	1.017	—	1.016	1.016	—

This table calls for a few remarks.

I have been able to get no good determinations of the specific gravity of the eggs of the frog, for unless the egg envelope is removed, the specific gravity is too high; and if the envelope is removed from the youngest eggs, they break badly in the solution. The toads for the two years correspond fairly well with

each other, but the drop in specific gravity began a little earlier in their growth in 1899 than in 1898. There is a great difference in the two series of frog tadpoles, however, that of 1898 being much lighter. Even allowing for possible individual variation, the discrepancy is still too great to be accounted for by the faults of the method.

In looking back at the history of the two cases I find an explanation, which is based upon the work of Galloway ('98), who found experimentally that tadpoles of *Rana*, *Amblystoma*, and *Bufo*, kept in a warm place, imbibed proportionately more water in reaching a certain stage than did those kept in the cold. My first series of observations (Table IV) was made on eggs of *Rana silvatica*, which were obtained in cleavage stages March 26, 1898. These were kept at room temperature and hatched out March 28-31 (two to five days), some reaching the length of 7 mm. by the latter date. The second series was collected April 11, 1899, and kept out of doors in a shallow basin on the ledge of a north window. On April 22 they had reached a length of 7 mm. (after a period of eleven days), although still in the egg, and on that day I brought them into the room to hasten their hatching. Since the specific gravity of the embryos in the second series was throughout so much greater than that of the first, I infer that they must have contained much less water, therefore have had smaller lymph spaces and smaller vacuolated cell regions and water spaces. That is, the embryos reared in a higher temperature must have imbibed more water than those exposed to the lower temperature.

But while the specific gravity depends on the amount of water absorbed by the tissues of the embryo, it also depends on the amount of animal matter. The proportional amount of this animal matter present has been ascertained by weighing, desiccating, weighing again, and computing what per cent of the first weight the dry weight is. Since the animals from one mass of eggs vary individually, I selected them on the basis of length, not age, each observation being based on five or ten individuals of a given length.

In the series of tadpoles of frog and toad I have found the specific gravity, the average fresh weight, the average dry

weight, and the percentage dry weight. They were dried in a partial vacuum over sulphuric acid.

TABLE V. — *RANA SILVATICA*.

DATE.	NUMBER OF TADPOLES.	LENGTH. (mm.)	AVERAGE FRESH WEIGHT.	AVERAGE DRY WEIGHT.	PER CENT DRY WEIGHT.	SPECIFIC GRAVITY.
April 13	5	2½	.00328	.00136	41.4	1.11 +
April 13	5	4	.00344	.00132	38.37	1.11 —
April 21	5	6	.00402	.00142	34.8	1.055
April { 22 25	10	7	.00448	.00126	28.1	1.055-1.037
April { 18 27	10	8-9	.00540	.00105	19.4	1.037-1.022
April 21	5	9	.00592	.00110	18.58	—
April 21	10	10-11	.00794	.00110	13.9	1.022-1.018
April 22	5	13-14	.02730	.00144	5.25	1.010
April 26	5	16-17	.04100	.00208	5	—
April 28	5	16	.05090	.00230	4.5	1.009-1.0065
May 1	5	20	.06750	.00356	5.2	1.007

TABLE VI. — *BUFO LENTIGINOSUS*.

DATE.	NUMBER OF TADPOLES.	LENGTH. (mm.)	AVERAGE FRESH WEIGHT.	AVERAGE DRY WEIGHT.	PER CENT DRY WEIGHT.	SPECIFIC GRAVITY.
May 1	10	3-4	.00115	.0005	44.3	1.037
May 1	10	4-5	.00217	.0007	32.2	1.037
May 2	10	6	.00339	.00065	19.1	1.025
May 3	10	7	.00354	.00062	17.5	1.022
May 10	10	8-10	.00867	.00077	8.8	1.018-1.016
May 10	10	10	.01477	.00122	8.2	1.016
May 10	10	12	.02496	.00196	7.8	1.018-1.016
May 11	10	13-15	.04455	.00327	7.3	—

These tables show :

1. That the animals, while continually increasing in total weight, really decrease in dry weight up to the age (about 10 mm. long in the frogs) where they take in food from without.

2. That the specific gravity decreases with the increase in volume, as one would expect if the increased volume is due to imbibition of water.

3. That the percentage of dry weight continues to decrease even after the absolute dry weight, owing to the acquisition of food from without, begins to increase. A similar set of results expressed in the form of a curve is given by Davenport ('97-99, p. 285).

In the case of the toad series growth was so slow that for the greater lengths (8 mm. and upwards) I took toads from out of doors. All had reached the feeding stage, the intestines of all being full, and since the conditions were the same and the lengths not greatly different, their specific gravities were essentially the same.

The preceding table was based on developing forms of Amphibians. I give also for comparison the relation which exists between dry weight and total weight in a few individuals of essentially adult fish.

TABLE VII.

	NUMBER OF INDIVIDUALS.	LENGTH. (mm.)	LIVE WEIGHT.	DRY WEIGHT.	PER CENT DRY WEIGHT.
Fundulus . .	2	32	.2090	.0454	21.7
Fundulus . .	1	35	.2780	.0622	22.6
Fundulus . .	2	44	.6336	.1490	23.6
Gasterosteus .	1	30	.1449	.0358	23.4
Gasterosteus .	1	60	1.4041	.3179	28.6

These fish were dried ten days. The larger the fish is, the greater the per cent of dry weight.

As one would expect, the armored stickleback has a greater per cent dry weight than Fundulus.

III.

The last section of the paper has reference to the location of the imbibed water in the tissues of the tadpole. I give three

cross-sections from tadpoles of *Rana silvatica* at different ages. They are in black and white, all solid cell tissue being printed black. They are all outlined with the camera to a magnification of 30 diameters.

As nearly as possible they are from corresponding regions of the body—the region just back of the thickened auditory epithelium. No. 1 is taken from a specimen $2\frac{1}{2}$ mm. long.



FIG. 1. — Cross-section *R. silvatica*, $2\frac{1}{2}$ mm. long, magnified 30 diam.; tissue black, spaces white.

Plainly there are here very few spaces which may contain water or lymph. The cells also are very crowded and show no vacuolation.

No. 2 is from a 10 mm. tadpole. The change is remarkable, especially in the development of the highly vacuolated mesenchyme. The neural canal is larger, while the cross-section of nervous tissue is not greatly increased.

The cavities of the oesophagus, intestine, and liver are large, and the pronephric tubules also increase the interior space.

As the best example of the change in individual cells, I call attention to those of the chorda, which are very strongly vacuolated.

The cross-section (Fig. 3) from a 20 mm. tadpole shows that, except for the cluster of cells on the right which forms the limb bud, the area of solid tissue has decreased greatly. The epidermis is very thin compared to either of the other examples, and the oesophagus and intestinal wall are not more than half as thick as in the preceding stage.



FIG. 2. — Cross-section *R. silvatica*, 10 mm. long, magnified 30 diam.

Table V shows that the actual tissue (dry weight) in specimen No. 2 must have been less than in No. 1. That the actual



FIG. 3. — Cross-section *R. silvatica*, 20 mm. long, magnified 30 diam.

tissue is greater in the 20 mm. tadpole is due to the fact that the tadpole has been taking in solid food for ten days.

RESULTS.

The specific gravity of certain fresh-water animals was determined and found to vary from 1.0095 (*Hydra viridis*) to a maximum of 1.0460 (Cypridopsis).

The movements of an animal are closely related to its density, and there is also a correlation between density and food habits.

Of the animals tested, Stentor may represent a typical case of specific gravity in little modified protoplasm. The heavier animals certainly have some specialized tissues which are

denser, while in the case of Hydra, the lightest, the extreme vacuolation of the inner layer may well indicate a less representative character of the protoplasm.

In the case of the developing animal the chief tissue to absorb water, and, therefore, the tissue of most rapid increase in bulk, is the mesenchyme. All of the walls of the internal organs, however, grow thinner and less dense as the animal increases in size.

This work has been carried on under Dr. Charles B. Davenport, whose suggestions are the basis of anything of value it may contain.

PAPERS CITED.

DAVENPORT, C. B.

'97-99. Experimental Morphology. xvii + 508 pp., 140 cuts. New York, The Macmillan Company.

GALLOWAY, T. W.

'98. Effect of Temperature on Growth of Tadpoles. *Science*. Vol. viii, n.s., No. 189, p. 178. [Abstract.]

LANDOLT, H., UND BÖRNSTEIN, R.

'94. Physikalisch-Chemische Tabellen. Zweite Auflage, xi + 563 pp. Berlin, J. Springer.

PLATT, JULIA B.

'99. On the Specific Gravity of Spirostomum, Paramœcium, and the Tadpole in Relation to the Problem of Geotaxis. *American Naturalist*. Vol. xxxiii, No. 385, pp. 31-38.

THE MOSAIC OF SINGLE AND TWIN CONES IN THE RETINA OF FISHES.¹

CARL H. EIGENMANN AND GEORGE DANIEL SHAFER.

THE eyes of fishes have served as the basis of numerous papers. A list of these dealing with the eye in its macroscopic aspect has been furnished by Ziegenhagen ('95), while those dealing with its minute structure have been enumerated by Krause ('86) and Cajal ('94).

During recent years the efforts have been largely in the direction of the application of the methods of Golgi and Ehrlich, chiefly to work out the vertical relationships of the various layers of the retina. The present paper will be devoted to the horizontal relationships of two elements in the retina of fishes, *i.e.*, the single and the twin cones.

Both elements are well known, and their relative positions have also received mention, as will be seen from the following summary of the literature.

The twin cones arise from two cells placed close together; their nuclei are usually just within the outer limiting membrane. The cone bodies are pressed together so that the faces in contact are flat. The outer segments are separate. The line joining the centers of the two elements of the twin cone may be termed the axis of a twin. The single cones vary greatly in their relative thickness when compared with the components of a twin. Quite frequently they are much thinner than the latter, and in some other instances their structure is strikingly different. In the eye of *Zygonectes*, for instance (Eigenmann ('99)), the basal portion of the single cones contains refractive granules, increasing in size outward where the series ends in a lenticular vacuolated body separating the granular from the distal portion. The twins do not possess these granules. In

¹ *Contributions from the Zoölogical Laboratory of the Indiana University, No. 26.*

Coregonus the outer segments of the single cones have a central deeper staining core. In this respect they agree with the rods. One of us was in doubt concerning these single cones, inclining to the opinion that they were rods (Eigenmann ('99), p. 548).

The rods are not taken into consideration in this paper. It may be said, however, that generally the number of rods is inversely proportional to the number of single cones.

The eyes examined were taken, for the most part, from museum specimens preserved in alcohol, and originally not intended for anatomical or histological purposes. The eyes were sectioned in paraffine, and the sections stained with hæmalum and eosine, or the Biondi-Ehrlich three-color mixture, or Weigert's hæmatoxylin; the latter gave good results even with the alcoholic material. No attempt has been made in this paper to describe the extent of variation in the patterns noted in different parts of the same retina.

The earliest notice that may have a possible bearing on the present subject is that of Guennelon (1686). According to Ziegenhagen, he noted that the retina of *Gadus æglifinus* is striped. We are not at all sure that this observation related to the arrangement of the twin and single cones.

The first undoubted notice that the twin and single cones may form a definite pattern was that of Hannover ('43), who figured the pattern of the "Rödspetten" and of the pike. Both patterns figured are those of our diagram *D*. We find the pattern of the pickerel to be that of diagram *H*.

Much later, Müller ('72, p. 59) says that in *Perca fluviatilis* the twins are in excess, with such an arrangement that each single cone is separated from its neighbor by the twins, not counting the rods. He also stated that in many fishes only single cones exist.

Nunneley ('58) and Krause ('68) described cones in the eel, and here, according to Krause, only single cones are found.

Friis ('79) examined a large series of fishes and found that in *Accipenser* and *Anguilla* only single cones exist. He found twin cones only in a large number of species, but states that in all of these, single cones are always to be found about the *ora*

serrata. Among the species that he enumerates as possessing twin cones only, there are certainly some in which single cones are regularly distributed. He found twin cones only in the retina of Scomber, Thynnus, Mugil, Gadus, Platessa, Hippoglossus, Rhombus, *Salmo trutta*, Coregonus, *Clupea harengus*, and *Clupea sprattus*.

He found both twin and single cones in *Belone rostrata*, Tinca, Ammodytes, Carassius, Abramis, Leuciscus. In the selachians examined, only rods are to be found.

Ryder ('95) discovered a regularity of arrangement of rods and cones in the larva of *Salmo salar*. The rods referred to are the single cones of authors. He believed this definite grouping of rods and cones to have some homology with the compound eye of the invertebrate. The arrangement he found is that of our pattern *D*.

Beer ('98) in a footnote calls attention to the fact that the cone mosaic is surprisingly plain and regular in *Scorpaena* and *Blennius*, and can be seen with the ophthalmoscope. He figures pattern *F*.

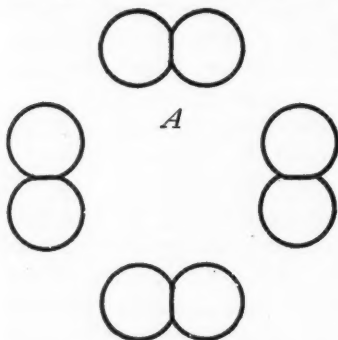
Eigenmann ('99) calls attention to the regularity of arrangement in *Zygonectes*. The pattern noted is *E*, a slight modification of that noted by Ryder in *Salmo*. He also found that in *Chologaster* the twins predominate over the single cones, and that in this genus the arrangement of the twins is a modification of pattern *C*.

Finally Eigenmann and Hansell ('99) in a short abstract state that the twin and single cones are arranged in a regular pattern, and that this pattern is either that described by Hannover and by Ryder for fishes, or a slight modification of this pattern.

The first notice of a regular alternation of twin and single cones is that by Hannover, and of the arrangement of twin and single cones, with a definite arrangement of the axes of the twin cones, is that by Ryder.

The work begun by Mr. G. Hansell under my direction has been continued by Mr. Shafer and myself, and a number of species have been examined to date. Mr. Hansell's work is incorporated in the present paper, credit being given under the

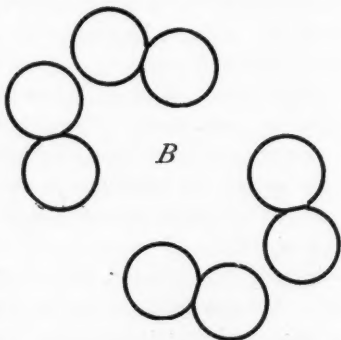
head of the species he examined. We have found that the arrangement of the twin and single cones is remarkably constant for any given species,¹



and that the arrangement differs considerably in different groups of fishes, but that the patterns in all of the species examined can be derived seriatim from one or the other of the patterns.

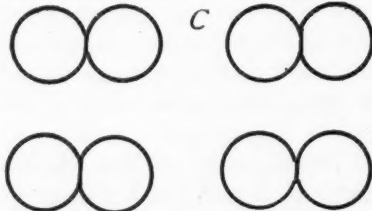
Pattern *A*, the pattern from which all others can most readily be derived, has not been found in any species as

yet, but slight modifications of it have. In this simple pattern there are twin cones only, and the axes of alternate rows of twins are parallel, while those of neighboring rows are at right angles to each other. A series of squares are formed in this way whose sides are the extended axes of four twin cones.



Pattern *B* is produced by a slight twisting of the axes of the twins so that if extended they would form a rhomb. This pattern was found in

Scorpæna porcus. The angles of the rhomb measure 53° and 127° . The actual conditions found in the eye are shown in Fig. 1.

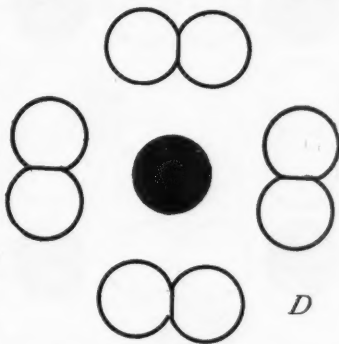


Pattern *C* is produced from *B* by a still further twisting of the axes of the twins till they are parallel

¹ The variation of the pattern in different parts of the same eye will be dealt with in a later paper.

to each other. This pattern was found in *Sebastodes elongatus* (Fig. 2). A similar but less regular arrangement was found by Eigenmann ('99) in *Chologaster cornutus* (Figs. 3, 4²). In the latter case there are also some single cones irregularly disposed among the twins.

Pattern *D* is formed from *A* by the addition of a single cone in the center of the square. This pattern has been known longer than any other, and is evidently the one described by Müller for *Perca*, in which he says "each single cone is separated from its neighbor by twins." It is found in the American and



the European species of *Perca* (Fig. 5), in which the single cones are of nearly the same size as the components of the twins, and in *Micropterus* (Fig. 9). It was also found in *Etheostoma caeruleum* (Fig. 6), *Apomotis cyanellus* (Fig. 7), and *Pimephales notatus* (Fig. 8). The three last eyes were pre-

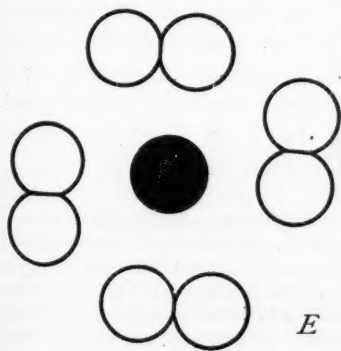
pared and the figures drawn by Mr. Hansell.

The closeness of the elements in the pattern and the size of the elements are seen to differ in the various species examined.

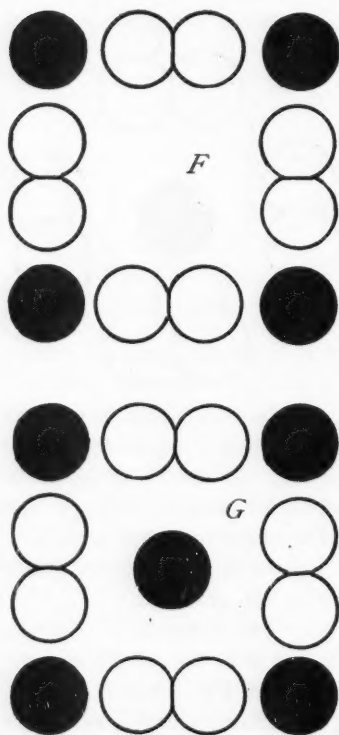
Pattern *E* is but a slight modification of pattern *D*, in which some of the twins have migrated along the faces of the squares so that while their

axes, if extended, still form squares, the lines separating the twins, if extended, form parallel lines instead of a continuous line. This condition was found by Eigenmann ('99) in *Zygonectes* (Figs. 10, 11).

Pattern *F* is formed by adding a single cone at each angle



of the square of pattern *A*. This gives us rows which answer to the description of Müller quoted above, but this pattern evi-

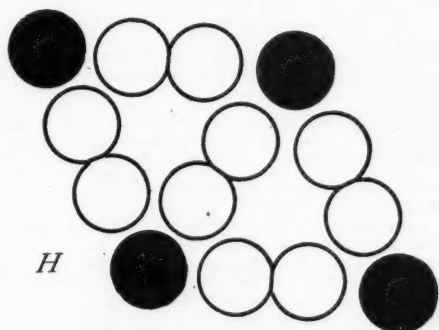


dently was not the one observed by him. This pattern was first figured by Beer ('98) in *Blennius*, in which the large hollow square formed is filled by a great number of rods. The actual pattern found in the eye of *Blennius* was of interest (Fig. 12), inasmuch as double series of twin cones, one with axes horizontal and one with axes vertical, were, in several places, interpolated without disturbing the pattern already present.

Pattern *G* is formed by adding a single cone in the center of the hollow square of pattern *F*. This pattern was described by Ryder ('95) in *Salmo*. A pattern but a little less regular was found in some larval *Coregonus* (Figs. 13-17).¹

¹ Inasmuch as these specimens of *Coregonus* were of interest in several respects, a brief note may be added to the above. The material examined consisted of recently hatched larvæ preserved in 70 per cent alcohol. The material came from the hatching station of the U. S. Fish Commission. The heads were imbedded in paraffine, sectioned and stained in hæmalum-eosine or in Biondi-Ehrlich's three-color mixture. Both methods gave excellent results. The twins alternate with the single cones in such a way that each is surrounded by four twins whose dividing plane points toward the space occupied by the single cone. The pattern is not mathematically accurate in the eye. Many of the twin cones are twisted, as it were, on their axes, and occasionally an extra single cone is to be found besides the single one in the unoccupied space between four twin cones, *i.e.*, at the angles of the square. Each component of a twin cone consists of a slender outer segment, a much thicker body, and a more or less vacuolated base

Pattern *H* is the most complicated found so far. The square of pattern *F* is converted into a rhomb with angles of 60° and 120° , and a twin cone is added whose axis forms a diagonal between the nearer angles of the rhomb. This makes two equilateral triangles whose sides are formed by twin cones, and



whose angles are occupied each by a single cone. This pattern has been found in *Lucius* (Figs. 18, 19).

No suggestion is offered as to the significance of these various patterns or the causes that have led to the various modifications.

In several species we have not so far been able to make out any regularity or, in fact, the nature of the cones. These are the catfishes and *Catostomus*, one of the suckers.

resting on the outer limiting membrane (Fig. 1). Below this membrane and exactly opposite each cone is a conical nucleus with a diameter less than that of the cone. With Biondi-Ehrlich the nuclei are stained a blue purple and the rest of the structures pink, so that there is no difficulty in separating parts. The single cones differ from the twins in possessing a central deeper staining core in the outer segment (Fig. 13). Besides these nuclei there are a few others, more spherical and slightly larger, just within the inner ends of this layer of cells — the rod nuclei. This inner layer of cells seems most abundant about midway between the optic nerve and the *ora serrata*. There are about two and one-half times as many of the outer nuclei as of these inner.

EXPLANATION OF FIGURES.

(Eigenmann, Figs. 1-5 and 10-19; Hansell, Figs. 6-9.)

All the figures were made from paraffine sections by the aid of the *camera lucida*. All but one of the figures were made under a magnification either of the Zeiss apochromatic 2 mm., or the Bausch and Lomb, $\frac{1}{4}$ objective.

(1) Pigment epithelium; (2) rods and cones; (3) outer nuclear layer; (4) outer reticular layer; (5) horizontal cells; (6) inner nuclear layer; (7) spongioblastic layer; (8) inner reticular layer; (9) ganglionic layer; (10) optic fibre layer; *cn.*, cones; *cn. nl.*, cone nuclei.

FIG. 1. — Arrangement of cones in *Scorpena porcus*, 2 mm.

FIG. 2. — The same of *Sebastes elongatus*.

FIG. 3. — Vertical section through the retina of *Chologaster papilliferus*, depigmented with chromic acid and stained with Biondi-Ehrlich's three colors, 2 mm.

FIG. 4 *a, b, c.* — A series of three oblique sections through the retina, 2 mm. (*a*) Passes from the outer margin of the retina to the base of the cone bodies. (*b*) Passes through the basal segments of the cones. (*c*) Passes through the cone nuclei.

FIG. 5. — Arrangement of cones in the retina of *Perca*, $\frac{1}{4}$.

FIG. 6. — The same of *Etheostoma caeruleum*, $\frac{1}{4}$.

FIG. 7. — The same of *Apomotis cyanellus*.

FIG. 8. — The same in *Pimephales notatus*.

FIG. 9. — The same in *Micropterus salmoides*, $\frac{1}{4}$.

FIG. 10. — Vertical section through the retina of *Zygonectes notatus*, 2 mm.

FIG. 11. — Tangential section of the retina at the depth of the cone bodies, showing the arrangement of the cones, 2 mm. and 6 mm.

FIG. 12. — Arrangement of the cones in *Blennius ocellaris*, 8 mm.

FIGS. 13-16. — Successive tangential sections through the retina of a newly hatched *Coregonus*. The sections represent the posterior face of successive sections through the same part of the retina, 2 mm.

FIG. 13. — Passes through the outer part of the inner segments of the cones and the inner ends of the pigment cells.

FIG. 14. — Passes through the bodies of the cones and shows to best advantage the arrangement of the cones.

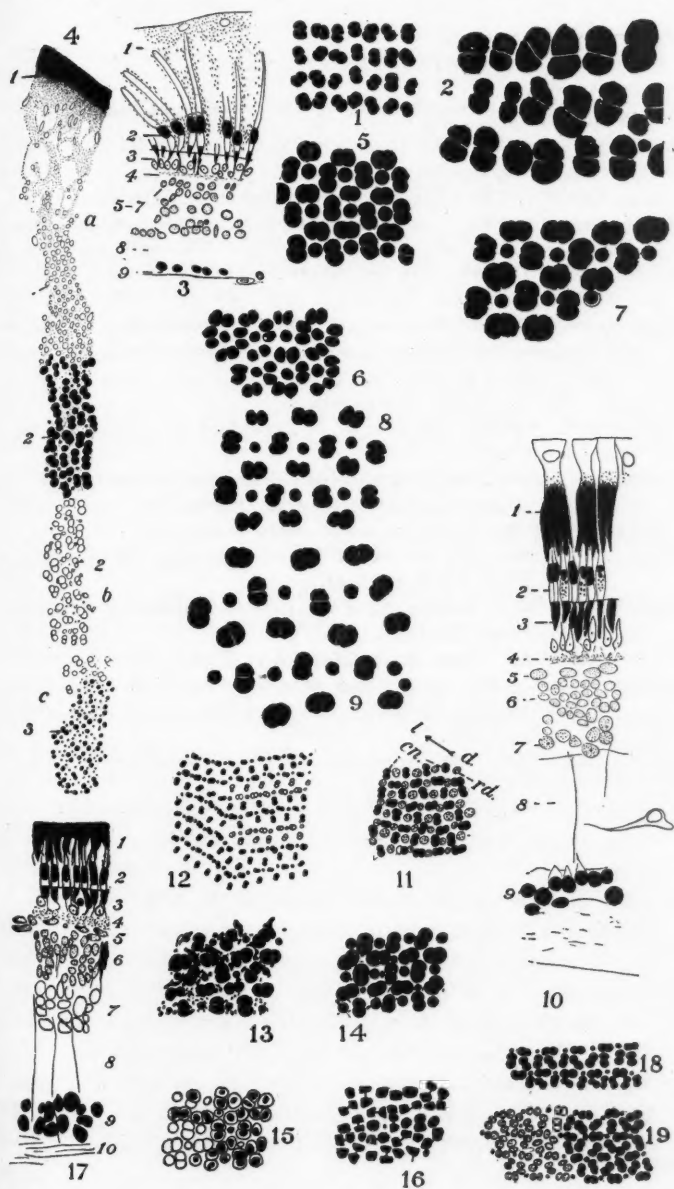
FIG. 15. — Section containing the inner ends of the cones and the outer ends of the nuclei belonging to them.

FIG. 16. — The middle of the cone nuclei.

FIG. 17. — Median section of the retina of a newly hatched *Coregonus* sp. (?), 2 mm.

FIG. 18. — Arrangement of the cones in *Lucius vermiculatus*.

FIG. 19. — Arrangement of the cones and cone cells in *Lucius vermiculatus*, the cones on the right, the cone cells on the left, of the figure, 2 mm.



PAPERS MENTIONED.

Those which we have not been able to examine directly are marked *.

- BEER, THEODOR. '98. Die Accommodation des Auges in der Thierreihe. *Wiener. klin. Wochenschrift*, Nr. 52.
- CAJAL, RAMON Y. '94. Die Retina der Wirbelthiere. Wiesbaden, 1894.
- CAJAL, RAMON Y. '96. Nouvelles contributions à l'étude histologique de la rétine. *Journ. de l'Anat. et de la Phys.* Vol. xxxii, p. 481.
- EIGENMANN, C. H. '99. The Eyes of the Amblyopsidæ. *Arch. f. Entwicklungsmechanik*. Bd. viii, p. 545.
- EIGENMANN, C. H., and HANSELL, G. '99. Preliminary Note upon the Arrangement of Rods and Cones in the Retina of Fishes. *Proc. Indiana Acad. Sci.* p. 167. 1898.
- FRIIS, G. '79. Fiskepiet. Kjøbenhavn.
- GUENNELON. *1686. *Nouvelles de la Republique des Lettres*. Mars. Article VIII.
- HANNOVER, ADOLPH. '43. Mikroskopiske Undersøgelser af Nervesystemet. *Vid. Sel. Naturvid. og. Mathem. Afsk.* X Deel.
- KRAUSE, W. *'68. Die membrana fenestrata der Retina.
- KRAUSE, W. '86. Die Retina der Fische. *Internat. Monatsschr. f. Anat. u. Hist.* Bd. iii, pp. 8, 42.
- MÜLLER, H. '72. Gesammelte und hinterlassene Schriften zur Anatomie und Physiologie des Auges. Leipzig.
- NUNNELEY. *'58. *Journ. Micr. Sci.* Vol. vi, Pl. XI.
- RYDER, JOHN A. '95. An Arrangement of the Retinal Cells in the Eyes of Fishes partially Simulating Compound Eyes. *Proc. Acad. Nat. Sci. Phila.* p. 161.
- ZIEGENHAGEN, PAUL. '95. Beiträge zur Anatomie der Fischeaugen. Berlin.

NOTE ON THE GENITAL ORGANS OF ZAITHA.

THOMAS H. MONTGOMERY, JR.

THE hemipterous genus *Zaitha* has a remarkable structure of the inner genital organs, particularly in the male, which deserves to be made known. Leidy (*History and Anatomy of the Hemipterous Genus Belostoma*) assumes, as I believe most, if not all, entomologists have subsequently done, that *Belostoma* and *Zaitha* are closely related genera of the same family. He states (*loc. cit.*, p. 59): "The principal marks of distinction between *Belostoma* and *Perthostoma* (*Zaitha*) are in the form of the promuscis; the form of the antennæ; the form, comparative size, and situation of the patch of pubescence on the hemielytra; the form of the posterior tibiæ; and the size and form of the caudal setæ."

Leidy gives a figure (Fig. 6) of the male genitalia of *Belostoma haldemanum*, and describes the testes as "irregularly rounded masses, about two lines in diameter, . . . composed (each) of a single long convoluted tube. From the testicle passes off the vas deferens; at first narrow, it gradually enlarges as it passes backwards, is a little contorted, and finally joins the one of the opposite side to form the ductus ejaculatorius." Very probably Leidy assumed that these organs were similarly constructed in *Zaitha*, for he makes no reference to the latter in this regard.

An examination of the male genital organs of *Zaitha* has shown me that they are very different from those of *Belostoma*, as described by Leidy (I have not been able to procure *Belostoma* for personal study). Some fifty males of *Zaitha* were dissected by me recently (November and December), and the genitalia in all showed the following structure (Fig. B). Each testis (the testes are distinct from one another) is a large organ composed of five capsules or follicles (2 and 3). Each capsule is thickened in its anterior portion, but the posterior three-fifths

of its course is represented by a narrow tube. These five capsules are loosely connected together by tracheæ, but there is no tunic investing them; and their proximal ends are connected by terminal fibres (1). Distally they connect (at 4) and so join the vas deferens (5); and the vas deferens of the right side joining with that of the left, these internal organs terminate in the ductus ejaculatorius (6). The vasa are thin-

walled, transparent tubes, considerably more delicate than the testes. In the drawing (Fig. B) I have represented the follicles more separated than they usually lie.

In this description I call a follicle of the testis the two portions numbered 2 and 3 in the figure. In the testes studied in December both these parts are filled with spermatozoa, and I can find on sections no evidences of earlier spermatogenetic stages; consequently, the testes must be considered physiologically mature. But is the portion marked 3 really a portion of a testicular follicle, or is it not

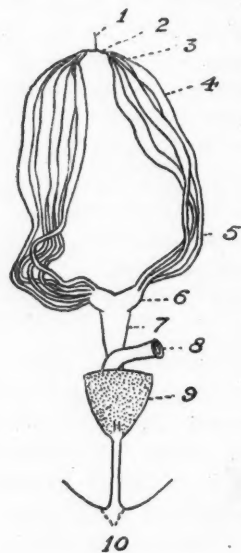


FIG. A.



FIG. B.

rather to be considered a vas deferens? If the latter alternative be correct, we should regard the five follicles (2) composing each testis to possess each a separate vas deferens (3), these five vasa deferentia joining posteriorly (at 4) to form a single vas (5). This point can be determined only by an examination of the organs in young individuals, with regard to whether in early stages spermatogonia and spermatocytes occur in the parts marked 3.

The ovaries differ in appearance according to the season of the year, *i.e.*, the state of growth of the ova. In June the ovarioles (follicles) are beaded in appearance. The small ova-

ries in December (Fig. *A*) have much the appearance of testes. Each ovariole is proximally attenuated (3), then enlarges (4), and distally is continued as a narrow tube (5). Perhaps, as in the testicle, the portion marked 5 should be regarded as an oviduct rather than a portion of an ovariole (follicle); in this case the portion marked 6 would be the undivided portion of the oviduct. Terminally is the vagina (7). (Fig. *A* represents all five ovarioles of the left ovary, but for the sake of clearness, only three ovarioles of the right ovary are shown; 8, the rectum; 9, the terminal ventral plate of the abdomen; 10, the outline of the posterior edge of the abdomen.) Proximally, the two ovaries are connected together by a fibrous thread (2, thread of Müller); and this thread is connected by another thread (1) to the pericardial wall. The dimensions in Fig. *B* should be doubled to be in the same scale of drawing as Fig. *A*.

From this description it will be seen that the female genital organs of *Zaitha* and *Belostoma* are quite similar, but that the male organs are very different. In *Belostoma* each testis consists of a single convoluted follicle; in *Zaitha*, of five distinct and well-separated, nearly straight follicles. Léon Dufour (*Recherches anatomiques et physiologiques sur les Hémiptères*) has not only given a most admirable description of the genitalia of Hemiptera, but also has insisted on their high value in taxonomy. Their worth seems to me also to be of great importance for classification. Consequently, when *Belostoma* and *Zaitha* differ so markedly in the structure of their male reproductive organs, we must conclude that these genera are by no means so closely related as they have been assumed to be; that in fact it might be proper to separate them into different families. *Zaitha* shows more relationship to *Nepa* in these structural characters than to *Belostoma*.

WILLEY ON THE ENTEROPNEUSTA.

MAYNARD M. METCALF.

DR. ARTHUR WILLEY has made such valuable contributions to our knowledge of the morphology of the lower Chordata that it is with high expectations one opens his recent memoir upon the Enteropneusta.¹ He describes in considerable detail many points in the anatomy of three species of Ptychodera (two of them new), of two species of Spengelina (one new), and of a Tornaria, all from the South Pacific, and also describes as new and distinct species belonging to the genus Ptychodera two West Indian forms, from Bimini (in the Bahamas) and from Jamaica. This anatomical part of the memoir is full of details of considerable interest to the student of the Enteropneusta, but hardly of such a nature as to permit description in this review. The author's observations, however, serve him as a foundation upon which to rest some very far-reaching theoretical conclusions, and to these it may be profitable to direct attention, referring to so much of the anatomy as may be necessary for a correct understanding of the basis for these conclusions.

Willey's first proposition is that "the gonads and gill slits were primarily unlimited in number and coextensive in distribution, the gonads having a zonary disposition and the gill slits occupying the interzonal depressions. The primary function of the gill slits was the oxygenation of the gonads, their secondary function being the respiration of the individual." In support of this contention that in the lower Chordata the series of gonads once extended much further forward, while the series of gill slits extended much further backward, the gill slits lying between the gonads and serving chiefly for their oxygenation,

¹ Willey, A. *Zoological Results*. Pt. iii, Enteropneusta from the South Pacific, with Notes on the West Indian Species. Cambridge, University Press, May, 1899.

the author urges (1) that in the Enteropneusta and Cephalochordata the number of gill slits is indefinite, new ones being added posteriorly throughout life; (2) that the number of gill slits has become reduced not only among the Vertebrata, but even within the group of the Enteropneusta, since one species, *Ptychodera auriantica*, has as many as seven hundred pairs, while another species, *P. mimeta*, never has more than forty pairs, these representing the two extremes so far as known; (3) that in the intestinal pores and ciliated grooves of certain Enteropneusta we have vestiges of the former posterior gill slits of the now abbreviated series. The intestinal pores occur in six species belonging to four genera. These pores may lie either close behind the branchial region or at the posterior end of the hepatic region. Schimkewitsch and Spengel have suggested that these pores may in some way be related to gill slits. In the Ptychoderidæ the pores are absent, but instead of them we have a pair of ciliated grooves extending from the anterior end of the hepatic region nearly to the posterior end of the body. In two species "these are not simple longitudinal furrows, but undergo metameric or interannular sacculations," the sacculi "strongly resembling gill pouches" not yet open to the exterior. Willey believes that the restriction of the gill slits to the anterior part of the body and of the gonads to the middle portion of the trunk took place after the development of a blood vascular system, which rendered the gonads no longer directly dependent upon the gill slits for oxygenation.

Certain species of Enteropneusta have two proboscis canals connecting anteriorly with the proboscis coelom and opening posteriorly by two pores on the dorsal side of the stalk of the proboscis, near where it joins the collar. The distal extremity of each of these canals may be swollen to form a considerable vesicle, or "end sac." Secondarily, in some species one (or both?) of the proboscis canals may be interrupted, so that the end sac, while opening to the exterior, has no longer any communication with the proboscis coelom. In certain adults, though not in the young, of one species, *Ptychodera carnosa*, Willey found that one of the two proboscis pores "may open" not onto the

posterior part of the dorsal surface of the proboscis stalk, as in other species, but "into the base of the medullary tube, somewhat behind the anterior neuropore."

"By a legitimate mental abstraction" Dr. Willey derives from this fact a "theory, as to the broad truth of which" he is himself "quite convinced," and which he states in these words: "The proboscis pore of the Enteropneusta is represented by and is homologous with the inner or cerebral opening of the neuro-hypophysial apparatus of the ascidian larva; the end sac of the Enteropneusta typically communicates internally with the coelom, but within the limits of the group we find signs of its emancipation from the coelom; the hypophysial canal of the ascidian larva has no relations with the body cavity, but it opens at one end into the medullary tube (cerebral vesicle) and at the other into the branchial sac at the base of the buccal cavity. Thus a special significance is given to the peculiar mode of origin of the ascidian subneural apparatus (gland and duct), and an explanation is forthcoming as to the apparent absence of anything like a proboscis pore in the ascidian larva." This adds another and startling hypothesis to the several that have been advanced as to the homologies of the ascidian neural gland. Allow me to refer for a moment to these.

Masterman's recent attempt to homologize the so-called notochordal pouch of the Hemichordata with the ascidian neural gland seems to imply a failure to understand the real nature of the latter organ. The notochordal pouch, so far as we can judge, is endodermal, a derivative of the pharynx. The neural gland of ascidians¹ is derived from the central nervous system, its duct is the anterior end of the central neural tube, and its aperture is usually regarded as the neuropore. The neural gland has no known relation to the endoderm, except that it opens into a portion of the pharynx which may be of endodermal origin, but which there is some reason to believe may be derived from the stomodæum.

¹ I say the neural gland of ascidians rather than of Tunicata, because the neural gland of certain tunicates, the Salpidæ, is of such a peculiar nature that it is difficult to compare it with that of the ascidians.

Wiley's attempt to homologize a portion of one or both of the proboscis canals¹ and their pores with the ascidian neural gland seems even a greater exercise of the imaginative faculty, for these structures in Ptychodera are not only mesodermal, but are a definite portion of the coelom. If they be homologous with one or both of the collar pores and collar canals, as seems not improbable, then they must be regarded as nephridial in their relationships, for Masterman has clearly demonstrated the nephridial nature of the collar canals in *Cephalodiscus*. Wiley, however, does not claim that the proboscis canals and collar canals of Ptychodera have been derived from the ascidian neural gland, but rather that the gland in the ascidians has been modified from a more primitive condition similar to that in certain adult specimens of *Ptychodera carnosa*. How such a proposition can be reconciled with the facts of the development of the gland in the ascidians, where it is formed wholly at the expense of the larval neural canal, it is very difficult to see. Wiley's statement that the "hypophysial canal" of the ascidian larva "opens into the medullary tube" is hardly accurate. It is morphologically a part of the medullary tube. Dr. Wiley must have had these facts clearly in mind, for he has himself published one of the most valuable descriptions of the ontogenetic development of the ascidian neural gland.²

The whole question of the homologies of the neural gland of tunicates is an exceedingly complicated and difficult one. It is by no means certain even that this gland is represented in the vertebrates by either of the two portions of that compound structure which is called the hypophysis cerebri, yet this homology proposed by Julin is comparatively simple, since the ascidian gland and one part of the vertebrate hypophysis are of neural origin. Wiley's theory is much more startling, for it claims a genetic relationship between a portion of the central nervous system in ascidians (the neural gland) and a portion of the coelom (the proboscis canals) in Enteropneusta. Yet the only foundation for the theory which I am able to find in his paper

¹ Wiley regards the condition with two proboscis pores as more primitive than that with one.

² Several further objections to the proposed homology might be urged, but it seems hardly wise to treat the theory too seriously.

is the fact that in certain adult individuals of one species of *Ptychodera* he finds sometimes one, sometimes the other, of the two proboscis pores opening "into the base of the medullary tube somewhat behind the anterior neuropore." In younger specimens he finds the single median proboscis pore opening somewhat in front of the "anterior neuropore." The occasional peculiarity he has observed in *Ptychodera carnosa* seems a rather narrow apex on which to found so broad a pyramid of theory.

Willey's third proposition as to regional pores and nephric tubules is best presented by copying his own table, which is self-interpreting, with the one explanation that the organs mentioned in the right-hand column are not intended to be represented as serially homologous with those in the preceding columns.

GROUP.	ARCHIMERIC SYSTEM.			ESSENTIAL ORGANS OF EXCRETION.
Ideal . . .	Protomeric pores	Mesomeric pores	Opisthomeric pores	Regional pore canals
Enteropneusta	Proboscis pores	Collar pores	Truncal pores (Spengelia)	Glomerulus
Cephalochorda	Præoral pit and Olfactory pit	Hatschek's nephridium	Lankester's brown funnels	Boveri's nephric tubules
Urochorda	Neuro-hypophysis (in part) ¹			{ Renal vesicles: Organ of Bojanus (Molgulidæ)
Vertebrata	Hypophysis (in part) ¹			{ Pronephros Mesonephros Metanephros

In some of the *Ptychoderidæ* Willey found that the collar nerve tube does not completely separate from the dorsal epidermis from which it arose, but that there are partially hollow connecting strands running from the nerve tube to the mid-dorsal line of the collar. The more or less interrupted lumina of these

¹ In part because cœlomic element is wanting.

hollow strands may in certain cases connect with the lumen of the central nerve tube. These hollow strands or "roots of the Ptychoderidæ," Willey says, "are genetically related to the epiphysial complex of Craniota; in the crucial nuchal region of the Enteropneusta are, therefore, to be found not the actual but the nearest possible approximation to the actual primordia of the . . . epiphysis cerebri of Craniota." Of course this *may be* true, yet it seems questionable if it be "profitable for doctrine."

Willey's fifth proposition he states as follows: "Just as the medullary tube of the collar is admittedly an invaginated portion of the dorsal nerve trunk,¹ so the medullary folds which arise and fuse to form the medullary tube are to be regarded as specializations of the anterior portion of the pleural folds which are retained in the Ptychoderidæ as the genital pleuræ." "The genital folds of Enteropneusta, the atrial folds of Amphioxus, and the medullary folds of Vertebrata belong to the system of pleural folds of the body wall, and are differentiated from a common primordium." In this connection it may be well to remember that Amphioxus has both medullary folds and atrial folds, and that there is no apparent relation between them.

Willey's sixth proposition refers to a recession of the "posterior neuropore" until it reaches and becomes associated with the blastopore ("primitive anus") to form the neurenteric canal. I do not, however, clearly understand the terms he uses.

Dr. Willey next discusses briefly the different regions of pseudo-chondroid tissue, *i.e.*, "stomochord, pygochord, and pleurochords."

Willey points out that the tongue bars of the gill region of the Enteropneusta "are not (ontogenetically) secondary, as they are in Amphioxus," and that "by their development, size, and

¹ Cf. Morgan (*Journal of Morphology*, vol. ix, 1894, p. 74). "We see in Balanoglossus that the *invaginated* dorsal nerve cord can correspond only to the anterior end of the nerve cord of Amphioxus, and that the *superficial* dorsal nerve path, stretching through the gill region, thence to the end of the body, must be the homologue of the remainder of the nerve cord of Amphioxus."

vascularity, they obviously constitute collectively the essential organs of respiration. In *Amphioxus* the functional importance of the tongue bars is greatly diminished; they are smaller in size and lower in vascularity than the primary bars, and their development is secondary."

In certain of the Enteropneusta the ventral edges of the gill slits are swollen on the pharyngeal surface, and these thickened areas of the walls of the successive gill slits are continuous, forming a pair of lateral ciliated pharyngeal ridges. These "arch round in front to unite in the epibranchial band," and represent the endostyle of *Amphioxus* and the Tunicata.

In one part of his memoir Dr. Willey describes certain phenomena of regeneration in *Ptychodera flava*, summarizing them as follows:

- (1) "When regeneration occurs in the region of the genital pleuræ the collar is regenerated from the pleuræ.
- (2) "The collar nerve tube is formed by the fusion of true medullary folds which are differentiated from the pleural folds.
- (3) "The zones of the collar are differentiated from the annulations of the body wall.
- (4) "In regenerating individuals the right and left proboscis pores are approximately equal.
- (5) "In regenerating individuals the lumen of the stomochord¹ is at first entire."

I trust the absence of comment in this review upon some of the proposed theories will not be interpreted as indicating my acceptance of these theories. The paper is noteworthy for the boldness and confidence with which it sets forth startling propositions.

THE WOMAN'S COLLEGE OF BALTIMORE,
January 9, 1900.

¹ Notochord of Bateson.

SYNOPSIS OF NORTH-AMERICAN INVERTEBRATES.

VII. THE CYCLOMETOPOUS OR CANCROID CRABS OF NORTH AMERICA.

MARY J. RATHBUN.

In the Cyclometopa the carapace is usually broader than long, regularly arched in front, and not rostrate; the epistome is short and transverse; the outer maxillipeds have the fifth joint articulated at the inner front angle of the fourth; there are nine pairs of branchiæ, their efferent channels opening at the sides of the endostome or palate; and the genital organs of the male are inserted at the bases of the last pair of trunk legs.

This tribe contains many well-known crabs, including all the large edible species of the United States—the common “blue crab,” or *Callinectes*, of our eastern coast, the stone crab (*Menippe*) of the Southern States, and the large *Cancer magister*, or common crab, of the Pacific coast.

The Cyclometopa, as represented in North America, may conveniently be subdivided into three families: first the Cancridæ, containing the genus *Cancer* with eleven species, some of which attain a large size and which frequent rocky and sandy bottoms, and the genera *Telmessus* and *Erimacrus*, hairy crabs inhabiting Bering Sea and the North Pacific and furnishing food for fur seals.

The remainder of the crabs of cancroid shape, that is, transversely oval or hexagonal and without projecting spines or natatory feet, are included in the family Pilumnidæ, many of which are small species inhabiting muddy places or living under stones or in crevices of rocks or sponges.

The family Portunidæ, or the swimming crabs, have, with one exception, the last pair of legs developed into a swimming

paddle. They include the widespread pelagic *Portunus sayi*, the "lady crab," or "calico crab" (*Ovalipes ocellatus*), and the edible Callinectes.

In the key which follows, the same terms are employed to indicate geographical distribution as in Professor Kingsley's keys to the Macrura, with two additions. Although the species of the southern half of Florida are excluded from the key as belonging properly to the West Indian fauna, those of the remainder of the Gulf coast are included. It has also seemed advisable to indicate by the letters *CH* those species whose northern limit is Cape Hatteras. The characters used are as follows:

A Alaska south.

P Puget Sound to San Francisco.

D Monterey to San Diego.

N Atlantic coast south to Cape Cod.

M Cape Cod to North Carolina.

S South Carolina to Florida.

G Gulf of Mexico.

CH Cape Hatteras, northern limit.

The bathymetrical limit is 100 fathoms.

KEY TO THE FAMILIES OF THE TRIBE CYCLOMETOPA.

- A.* Antennulæ folded longitudinally. Outer maxillipeds long, overlapping the epistome CANCRIDÆ Latreille, Alcock
- A'.* Antennulæ folded transversely or obliquely transversely. Outer maxillipeds usually not overlapping the epistome.
 - B.* Last pair of legs not modified for swimming
PILUMNIDÆ Leach = XANTHIDÆ Alcock
 - B'.* Last pair of legs usually modified for swimming, with the last two joints compressed, very broad and paddle-like. Carapace widest at the last antero-lateral marginal spine. Usually from 5 to 9 antero-lateral spines or teeth . . . PORTUNIDÆ Leach, Miers

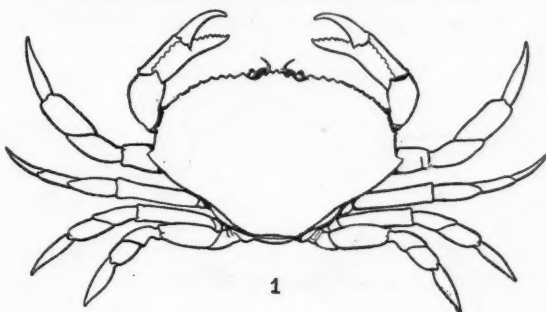
KEY TO THE GENERA OF THE FAMILY CANCRIDÆ.

- A.* Buccal cavity completely closed by the outer maxillipeds . . Cancer
- A'.* Buccal cavity not completely closed by the outer maxillipeds.
 - B.* Carapace broader than long, pentagonal Telmessus
 - B'.* Carapace longer than broad, suboval Erimacrus

THE SPECIES OF CANCRIDÆ.

Genus *Cancer* Linnæus.*Key to Species.*

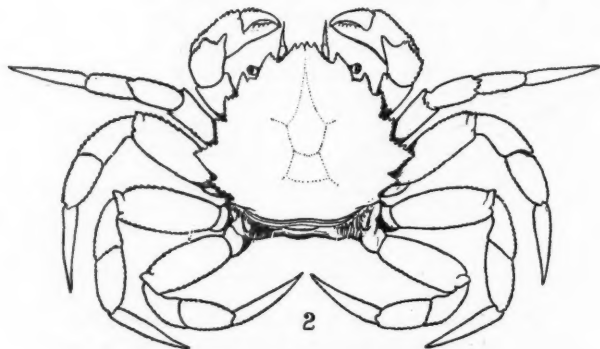
- A. Ambulatory legs very broad and flat, especially those of the last pair
C. magister Dana APD
- A'. Ambulatory legs of moderate width.
- B. Fronto-orbital width small, about one-fifth width of carapace.
 Front strongly advanced beyond outer orbital angles
C. productus Randall APD
- B'. Fronto-orbital width more than one-fifth width of carapace. Front
 not greatly advanced beyond outer orbital angles.

FIG. 1. — *Cancer magister*.

- C. Color on the fingers extending from the tip not more than half the length of the fingers.
- D. Carpus of cheliped with two spines at inner angle, one below the other.
- E. Antero-lateral teeth shallow, projecting little from the carapace. Carapace very slightly areolated
C. gracilis Dana APD
- E'. Antero-lateral teeth strong, projecting well out from the carapace.
- F. Fronto-orbital width one-third the width of the carapace. Carapace strongly areolated
C. gibbosulus (de Haan) APD
- F'. Fronto-orbital width nearly half the width of the carapace. Carapace slightly areolated
C. jordani Rathbun, sp. nov.,¹ D

¹ Type, U. S. Nat. Mus. No. 22868, Monterey Bay, Harold Heath, collector. The new species noticed in this paper will be described in full in the *Proceedings of the United States National Museum*.

- D.* Carpus of chelipeds with one spine at inner angle.
E. Antero-lateral teeth with dentate or spinulose margins.
F. Crests on hand feeble, granulate
C. anthonyi Rathbun *D*
F. Crests on hand strong, the upper ones spinulose
C. borealis Stimpson *NM*
E. Antero-lateral teeth with margins simply granulate
C. irroratus Say *NMS*
C. Color on the fingers extending from the tip more than half the length of the fingers.
D. Fronto-orbital width one-third the width of the carapace
C. antennarius Stimpson *APD*
D. Fronto-orbital width nearly one-half the width of the carapace. Carapace strongly areolated.

FIG. 2. — *Telmessus cheiragonus*.

- E.* Front truncate. Movable finger almost entirely dark-colored . . . *C. oregonensis* (Miers) *APD*
E. Front not truncate. Movable finger not more than two-thirds dark-colored . . . *C. amphietus* Rathbun *D*
 Genus *Telmessus* White *T. cheiragonus* (Tilesius) *AP*
 Genus *Erimacrus* Benedict *E. isenbeckii* (Brandt) *A*

KEY TO THE GENERA OF THE FAMILY PILUMNIDÆ.

- A.* The ridges that define the efferent branchial channels, if present, are low, and are confined to the posterior part of the endostome, never reaching to the anterior boundary of the buccal cavern.
B. Fronto-orbital border less than half the greatest width of the carapace.

- C. Antero-lateral margin continued to the angle of the buccal cavity. Carapace eroded Glyptoxanthus
- C'. Antero-lateral margin ending at the orbit.
 - D. A deep notch in the anterior border of the merus of the external maxillipeds. Carapace nodose Daira
 - D'. No deep notch in the anterior border of the merus of the external maxillipeds. Carapace not nodose
Cycloxanthops
- B'. Fronto-orbital border half or more than half the greatest width of the carapace.
 - C. Chelipeds with a circular cavity on the anterior margin between the carpus and manus Carpoporus
 - C'. Chelipeds without a circular cavity on the anterior margin.
 - D. Carpal joints of ambulatory legs armed above with a horned or lunate crest Heteractæa
 - D'. Carpal joints of ambulatory legs not armed with a horned crest.
 - E. Carapace transversely oval.
 - F. Ambulatory legs spiny or granular on the upper border Xanthias
 - F'. Ambulatory legs not spiny nor granular on the upper border.
 - G. Four or more well-marked antero-lateral teeth, excluding the orbital
Leptodius
 - G'. Four antero-lateral teeth (besides the orbital), the first of which is low and more or less fused with the orbital
Eurypanopeus
- E'. Carapace more or less hexagonal or subquadrate.
 - F. Carpal and propodal joints of ambulatory legs more or less cristate Lophopanopeus
 - F'. Carpal and propodal joints of ambulatory legs not cristate.
 - G. Ambulatory legs spinulose. Micropanope
 - G'. Ambulatory legs not spinulose.
 - H. Three antero-lateral teeth besides the orbital, the second normal tooth, or that next the orbital, being obsolete
Glyptoplax
 - H'. Four antero-lateral teeth besides the orbital, the second normal tooth, or that next the orbital, being sometimes partially united with the orbital, but never obsolete.

- J.* Terminal segment of abdomen of male oblong. Carapace subquadrate, narrow (length about three-fourths width), approaching the Catometopa. Prominent transverse dorsal ridges

Rhithropanopeus

- J.* Terminal segment of abdomen of male subtriangular. Carapace when subquadrate, wider than the preceding.

K. Front arcuate. Carapace hexagonal. Neopanope

K'. Front with truncate or sinuous lobes.

L. Front very narrow and advanced. Postero-lateral margins strongly converging. Carapace hexagonal

Hexapanopeus

L'. Front of moderate width. Postero-lateral margins not strongly converging. Carapace subquadrate

Eupanopeus

A'. The ridges that define the efferent branchial channels extend to the anterior boundary of the buccal cavern and are often very strong.

B. Fronto-orbital border just about half or less than half the greatest breadth of the carapace, which is broad and transversely oval.

C. Antero-lateral margin much shorter than the postero-lateral. Front with two simple lobes Eurytium

C'. Antero-lateral and postero-lateral margins subequal. Front with two lobulate lobes Menippe

B'. Fronto-orbital border much more than half the greatest breadth of the carapace.

C. Carapace nodose Lobopilumnus

C'. Carapace not nodose, but often granulate or spinous, and usually hairy Pilumnus

THE SPECIES OF PILUMNIDÆ.

- Genus Glyptoxanthus A. Milne Edwards . . . *G. erosus* (Stimpson) *G*
 Genus Daira de Haan *D. americana* Stimpson† *D*
 Genus Cycloxanthops Rathbun . . . *C. novemdentatus* (Lockington)^a *D*
 = *C. californiensis* Rathbun
 Genus Carpororus Stimpson *C. papulosus* Stimpson *M(CH)* *G*
 Genus Heteractaea Lockington *H. lynata* (Milne Edwards and Lucas) *D*
 Genus Xanthias Rathbun *X. taylori* (Stimpson) *D*
 Genus Leptodius A. Milne Edwards *L. agassizii* A. Milne Edwards
 M(CH) *G*
 Genus Eurypanopeus A. Milne Edwards . . *E. depressus* (Smith) *MSG*
-
- Genus Lophopanopeus Rathbun.

Key to Species.

- A. Upper margin of meral joints of ambulatory legs not spinulosus.
B. Hands smooth, without lobe or tooth on upper margin
L. bellus (Stimpson) APD
B'. Hands with one or more lobes or teeth on upper margin.
C. Carpus of cheliped smooth or nearly so.
D. Color of pollex running far back on hand
L. frontalis Rathbun D
D'. Color of pollex not running back on hand
L. heathii Rathbun, sp. nov.,³ D
C'. Carpus of cheliped very rough.
D. Carpal joints of ambulatory legs strongly bilobed.
E. Carpus of cheliped covered with reticulating ridges enclosing pits of irregular shape
L. leucomanus (Lockington) D
E'. Carpus of chelipeds covered with tubercles
L. diegensis Rathbun, sp. nov.,⁴ D
D'. Carpal joints of ambulatory legs slightly bilobed
L. lockingtoni Rathbun, sp. nov.,⁵ D

¹ California, on the authority of A. Milne Edwards.

² Mr. S. J. Holmes has compared specimens (not types) determined by Lockington as *Xantho novemdentatus*, with *C. californiensis*, and pronounces them the same. If the species are identical, Lockington's measurements of his type must be erroneous.

⁸ Type, U. S. Nat. Mus. No. 22870, Monterey Bay, Harold Heath, collector.

⁴ Type, U. S. Nat. Mus. No. 4281, San Diego, 10 fathoms, H. Hemphill, collector.

⁶ Type, U. S. Nat. Mus. No. 19973, San Diego Bay, Steamer *Albatross*, collector. *Xanthodes latimanus* Lockington is probably a *Lophopanopeus*, but is not determinable with certainty.

A'. Upper margin of meral joints of ambulatory legs spinulous

L. distinctus Rathbun G

Genus *Micropanope* Stimpson.

Key to Species.

A. Second normal tooth of the antero-lateral margin absent

M. sculptipes Stimpson SG

A'. Second normal tooth of the antero-lateral margin present

M. xanthiformis (A. Milne Edwards) M(CH)

Genus *Glyptoplax* Smith.

Key to Species.

A. Last tooth of lateral margin small but well marked. Median lobe of the upper orbital margin strongly arcuate

G. smithii A. Milne Edwards M(CH)G

A'. Last tooth of lateral margin rudimentary. Median lobe of the upper orbital margin subtruncate. . . . *G. pusilla* (A. Milne Edwards) G

Genus *Rhithropanopeus* Rathbun *R. harrisii* (Gould) NMSG

Genus *Neopanope* A. Milne Edwards.

Key to Species.

A. Dactylus of larger hand with a large basal tooth

N. packardii (Kingsley) G

A'. Dactylus of larger hand without a large basal tooth.

B. Fingers white or light horn-color. Antero-lateral teeth sharp and much produced *N. texana* (Stimpson) SG

B'. Fingers black or dark-colored in the males. Antero-lateral teeth blunter and less produced . . . *N. texana sayi* (Smith) MS

Genus *Hexapanopeus* Rathbun

H. angustifrons (Benedict and Rathbun) MSG

Genus *Eupanopeus* Rathbun.

Key to Species.

A. Carpus of cheliped with a groove parallel with its distal margin. Color of immovable finger not extending beyond the line of color on the movable finger *E. occidentalis* (Saussure) S

A'. Carpus of cheliped without groove. Color of immovable finger extending beyond the line of color on the movable finger

E. herbstii (Milne Edwards) MSG

Genus *Eurytium* Stimpson *E. limosum* (Say) MS

Genus *Menippe* de Haan.

Key to Species.

A. Surface of carapace almost smooth. Antero-lateral teeth or lobes shallow or little projecting . . . *M. mercenaria* (Say) M(CH)SG

A'. Surface of carapace anteriorly nodose. Antero-lateral teeth strong, projecting well out from the carapace . *M. nodifrons* Stimpson S

Genus *Lobopilumnus* A. Milne Edwards . . . *L. agassizii* Stimpson G

Genus *Pilumnus* Leach.

Key to Species.

A. Carapace concealed by a short, thick pubescence, which, when removed, discloses tubercles on the gastric and hepatic regions

P. pannosus Rathbun G

A'. Carapace, when covered by a short, thick pubescence, not having the gastric region tuberculate.

B. Superior orbital border with one or few long spines.

C. Superhepatic region unarmed

P. spinohirsutus (Lockington) D

C'. Superhepatic region armed with spines or spinules

P. sayi Rathbun M(CH)SG

B'. Superior orbital border either entire or armed with denticles or spinules.

C. Outer surface of smaller hand only partially covered with tubercles or spines *P. lacteus* Stimpson G

C'. Outer surface of smaller hand entirely covered with tubercles or spines *P. floridanus* Stimpson G

KEY TO THE GENERA OF THE FAMILY PORTUNIDÆ.

A. Last pair of legs broad, modified into swimming paddles.

B. Carapace decidedly transverse; antero-lateral margins cut into nine teeth.

C. Movable portion of the antenna excluded from the orbital cavity by a prolongation of the basal joint of the antenna

Charybdella

C'. Movable portion of the antenna not excluded from the orbit.

D. No longitudinal ridge on the palate *Arenæus*

D'. A longitudinal ridge on the palate.

E. Abdomen of male L-shaped *Callinectes*

E'. Abdomen of male triangular *Portunus*

B'. Carapace not very broad; antero-lateral margins cut into five teeth.

C. Last tooth of antero-lateral margin developed into a spine, longer than the other teeth or spines *Bathynectes*

C'. All antero-lateral teeth similar *Ovalipes*

A'. Last pair of legs narrow, with dactylus lanceolate *Carcinides*

THE SPECIES OF PORTUNIDÆ.

Genus *Charybdella* Rathbun *C. rubra* (Lamarck) S

Genus *Arenæus* Dana *A. cribrarius* (Lamarck) MSG

Genus *Callinectes* Stimpson.

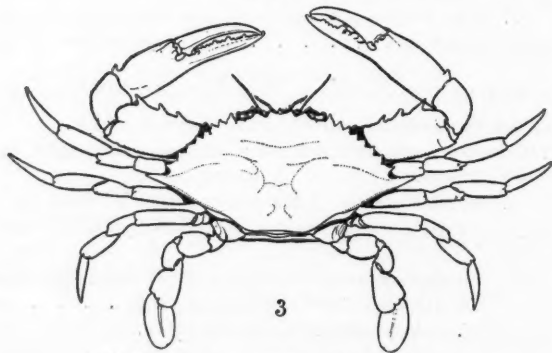
Key to Species.

- A. Front with four intraorbital teeth.
 - B. Median pair of frontal teeth without an accessory tooth
C. sapidus Rathbun NMSG
 - B'. Median pair of frontal teeth, each with an accessory tooth on its inner margin *C. sapidus acutidens* Rathbun SG
- A'. Front with six intraorbital teeth.
 - B. Intramedial region broad, its anterior width about three times its length. Posterior margin of antero-lateral teeth longer than the anterior *C. ornatus* Ordway SG
 - B'. Intramedial region narrow, its anterior width about twice its length. Second to sixth antero-lateral teeth equilateral
C. dana Smith SG

Genus *Portunus* Fabricius.

Key to Species.

- A. Carapace wide; antero-lateral margin the arc of a circle with long radius, whose center is near the posterior margin of the carapace
Subgenus *Portunus* = *Neptunus* de Haan

FIG. 3. — *Callinectes sapidus*.

- B. First eight lateral spines or teeth subequal.
 - C. Front with six intraorbital teeth *P. sayi* (Gibbes) NMSG
 - C'. Front with eight intraorbital teeth
P. gibbesii (Stimpson) MSG
- B'. Second, fourth, and sixth lateral teeth or spines smaller than the others *P. xantusii* (Stimpson) PD
- A'. Carapace narrow; antero-lateral margin the arc of a circle with short radius, whose center is near the center of the cardiac region
Subgenus *Achelous* de Haan (including *Hellenus* and *Amphitrite* de Haan).

B. Carapace with rounding posterior corners.

C. Posterior of the lateral spines of the carapace exceeding the other spines or teeth but little if at all.

D. Three spines on manus *P. anceps* (Saussure) M(CH)

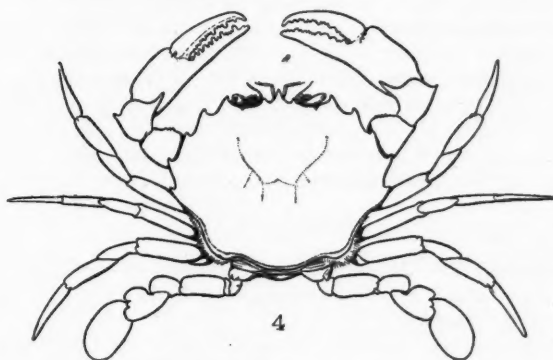


FIG. 4.—*Ovalipes ocellatus*.

D'. Two spines on manus.

E. Superior outer surface of manus smooth, iridescent
P. ordwayi (Stimpson) G

E'. Superior outer surface of manus with a longitudinal, tuberculated ridge.

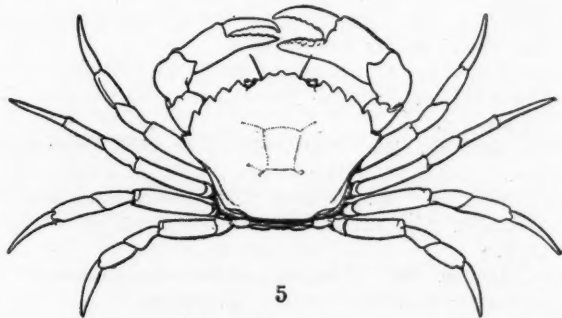


FIG. 5.—*Carcinides manas*.

F. Front with eight intraorbital teeth

P. spinimanus (Latreille) MSG

F'. Front with six intraorbital teeth

P. depressifrons (Stimpson) S

C. Posterior of the lateral spines of the carapace much longer than the other lateral spines or teeth

P. sebæ (Milne Edwards) *M(CH)*

B'. Carapace with sharp posterior angles

P. spinicarpus (Stimpson) *M(CH)G*

Genus *Bathynectes* Stimpson *B. superba* (Costa) *M*

Genus *Ovalipes* Rathbun *O. ocellatus* (Herbst) *NMSG*

Genus *Carcinides* Rathbun *C. manas* (Linnæus) *M*

BIBLIOGRAPHY.

- SAY, THOMAS. '17. An Account of the Crustacea of the United States. *Journ. Acad. Nat. Sci. Philadelphia*. Vol. i, pt. i, pp. 57-63, 65-80, 97-101, Pl. IV.
- SAY, THOMAS. '18. Appendix to the Account of the Crustacea of the United States. *Journ. Acad. Nat. Sci. Philadelphia*. Vol. i, pt. ii, pp. 445-458.
- MILNE EDWARDS, H. '34. Histoire naturelle des crustacés. Vol. i, chap. iv, pp. 363-468, and atlas.
- GOULD, A. A. '41. A Report on the Invertebrata of Massachusetts. Crustacea. Pp. 321-341.
- GIBBES, LEWIS R. '50. On the Carcinological Collections of the United States. *Proc. Amer. Assoc. Adv. Sci.* Vol. iii, pp. 167-201.
- DANA, JAMES D. '52. Crustacea of the United States Exploring Expedition. Vol. i, pp. 142-306, and atlas.
- STIMPSON, WILLIAM. '57. Crustacea and Echinodermata of the Pacific Shores of North America. *Journ. Boston Soc. Nat. Hist.* Vol. vi, pp. 444-532.
- STIMPSON, WILLIAM. '59. Notes on North American Crustacea, No. I. *Ann. Lyc. Nat. Hist. New York*. Vol. vii, pp. 49-93, Pl. I.
- STIMPSON, WILLIAM. '60. Notes on North American Crustacea, No. II. *Ann. Lyc. Nat. Hist. New York*. Vol. vii, pp. 176-246, Pls. II, V.
- ORDWAY, ALBERT. '63. Monograph of the Genus *Callinectes*. *Journ. Boston Soc. Nat. Hist.* Vol. vii, pp. 567-583.
- MILNE EDWARDS, A. '65. Études zoologiques sur les crustacés récents de la famille des cancériens. *Nouv. Arch. Mus. Hist. Nat. Paris*. Tome i, pp. 177-308, Pls. XI-XIX.
- SMITH, S. I. '69. Notes on New or Little-Known Species of American Cancroid Crustacea. *Proc. Boston Soc. Nat. Hist.* Vol. xii, pp. 274-289.

- MILNE EDWARDS, A. '73-80. Les crustacés de la région Mexicaine.
- VERRILL, A. E., and SMITH, S. I. '74. Report upon the Invertebrate Animals of Vineyard Sound. *Rept. U. S. Commissioner of Fish and Fisheries for 1871 and 1872.*
- LOCKINGTON, W. N. '77. Remarks on the Crustacea of the West Coast of North America, with a Catalogue of the Species in the Museum of the California Academy of Sciences. *Proc. Cal. Acad. Sci.* Vol. vii, pp. 94-108, Sept. 4, 1876. •
- KINGSLEY, J. S. '78-79. List of Decapod Crustacea of the Atlantic Coast, whose Range embraces Fort Macon. *Proc. Acad. Nat. Sci. Philadelphia for 1878.* Pp. 316-328 (1878), 329-330 (1879).
- SMITH, S. I. '79. The Stalk-Eyed Crustaceans of the Atlantic Coast of North America North of Cape Cod. *Trans. Conn. Acad. Sci.* Vol. v, pp. 27-136, Pls. VIII-XII.
- KINGSLEY, J. S. '80. On a Collection of Crustacea from Virginia, North Carolina, and Florida. *Proc. Acad. Nat. Sci. Philadelphia for 1879.* Vol. xxxi, pp. 383-427.
- RATHBUN, RICHARD. '84. The Fisheries and Fishery Industries of the United States. Crustaceans. Pt. v, pp. 763-830. Pls. CCLX-CCLXXV, in separate volume.
- SMITH, S. I. '86. Report on the Decapod Crustacea of the Albatross Dredgings off the East Coast of the United States during the Summer and Autumn of 1884. *Rept. U. S. Commissioner of Fish and Fisheries for 1885.* Pp. 605-705.
- BENEDICT, JAMES E., and RATHBUN, MARY J. '91. The Genus *Panopeus*. *Proc. U. S. Nat. Mus.* Vol. xiv, No. 858, pp. 355-385, Pls. XIX-XXIV.
- BENEDICT, JAMES E. '92. Corystoid Crabs of the Genera *Telmessus* and *Erimacrus*. *Proc. U. S. Nat. Mus.* Vol. xv, No. 900, pp. 223-230, Pls. XXV-XXVII.
- NEWCOMBE, C. F. '93. List of Crustacea (Brachyura and part of Anomura) in the Provincial Museum of British Columbia, with notes on their distribution. *Bull. Nat. Hist. Soc. British Columbia*, 1893. Pp. 19-30, Pls. II-V.
- RATHBUN, MARY J. '96. The Genus *Callinectes*. *Proc. U. S. Nat. Mus.* Vol. xviii, No. 1070, pp. 349-375, Pls. XII-XXVIII.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Anthropological Notes.—The rate of erosion of the gorge of Niagara has been variously estimated, and the length of time that has elapsed since the river began its cutting has been shortened or lengthened to correspond. Owing to the problems connected with the relations of early man in America to the glacial epoch, the discussion of the value of Niagara as a chronometer, in No. 4, Vol. XXXI, of the *Bulletin of the American Geographical Society*, will be of interest to anthropologists. Professor Tarr summarizes the results of the many investigations in the following words: "Gilbert says that the problem of the age of Niagara cannot 'be solved by a few figures on a slate, nor yet by the writing of many essays.' To this every one who has given attention to the problem must assent. The longer the study, the more complex the problem appears, and we are bound to conclude that Niagara is not a good chronometer. Until more evidence has been obtained concerning the length of the overflow at Nipissing Pass, which some believe to have been long, others short, we are bound to remain in doubt whether the age is from 5000 to 10,000 years or from 30,000 to 50,000 years."

In the *American Anthropologist* for October, 1899, appears a second paper by Mr. W. H. Holmes upon "Preliminary Revision of the Evidence relating to Auriferous Gravel Man in California." Mr. Holmes devotes his attention chiefly to the Calaveras skull, the most important of the human remains reported from the auriferous gravels. He regards this supposed Tertiary relic as quite modern, probably the skull of a Digger Indian. Notwithstanding his masterly summing up of the evidence for the negative, the case cannot be considered closed until the facts presented by Becker, Wright, and King have been explained. Mr. Holmes is unjust in his intimation that the possessors of the skull have been neglectful of their obligation in not taking further steps to prove its authenticity during the thirty-three years that it has been in Cambridge. Professor Whitney adequately described the skull in his volume on *The Auriferous Gravels of the Sierra Nevada of California*. It was always accessible to any one

wishing to examine it. Further evidence was obtainable only in the locality whence it came. No opportunity to seek such evidence has yet occurred during the short period in which the skull has been in the possession of the Peabody Museum.

The sixth summer meeting of "The American Association to Promote the Teaching of Speech to the Deaf" was held at the Clarke School for the Deaf, Northampton, Mass., in June, 1899. In his presidential address Dr. Alexander Graham Bell reviewed the history of the association from the time of its foundation in 1890. A condensed account was also given of the present condition of instruction in speech-teaching in the United States. Only a few years ago silent methods of instruction of deaf-mutes were everywhere in vogue; now speech is used as a means of instruction with the majority of such pupils (53.1 per cent), and the total number taught speech and speech-reading amounts to 6460, or 61.4 per cent of the whole. There is a steady increase in the percentage of speech-teaching, and Dr. Bell believes that the time is not far distant when speech will be taught to every deaf child in America. In a reprint from *The Association Review*, Dr. Bell adds a number of tables of statistics compiled from the *American Annals of the Deaf*. These show the number of schools, pupils, teachers, and give lists of the schools, with their location, official names, directors, etc.

F. R.

GENERAL BIOLOGY.

A Study of Heredity among the Deaf.¹—We are indebted to Professor Edward Allen Fay for an important contribution to the data of heredity. The collection of the large mass of material and publication of the expensive tables were made possible by a liberal use of the funds of the Volta Bureau, an institution endowed by Dr. Alexander Graham Bell "for the increase and diffusion of knowledge relating to the deaf."

The inquiry was begun in 1889. Circulars containing questions to be answered were distributed widely among heads of schools for the deaf, the deaf themselves, and their relatives and friends. Facts were gathered also from journals for the deaf, school reports, and

¹ Fay, E. A. *Marriages of the Deaf in America*. Washington, The Volta Bureau, 1898 (1899). vii, 527 pp., 8vo.

returns of census enumerators. The result was that more or less complete returns were received of 4471 marriages in which one or both of the partners were deaf. After deducting marriages of less than a year's standing, the total number of marriages of which the results in regard to offspring are reported is 3078, and number of children is 6782. These numbers are large enough to promise fairly trustworthy results.

The first third of the book is taken up with a discussion of the results, and the rest is devoted to a tabular statement giving the details in regard to each marriage. This is followed by an index.

Within the space of a review one cannot do more than refer to some of the conclusions which are of especial interest. Passing over the statistics in regard to the relative fertility of the deaf and the hearing, the proportion of deaf children in the total marriages of the deaf, etc., we come to a comparison between the proportion of deaf children born when both parents are deaf and the number when one parent only is in this condition, and we find the surprising result that in the first case there are only 8.458 per cent of deaf children, while in the second there is a considerably larger percentage, namely, 9.856. This would seem to upset all one's ideas of heredity. But the anomaly is explained to a great extent when we take into consideration the nature of the deafness, whether congenital or acquired, the ancestry of the parents, and their relationship to one another.

The author calls attention to the fact that deafness may be due to a number of causes, such as various infectious diseases, malformation of various auditory organs, and the like. It is not deafness as such that is inherited, but some tendency to disease, or some abnormal habit of growth. This makes it difficult to distinguish deafness which is congenital and that which is adventitious, even when the patient can be examined; and it is still more difficult to make the distinction from the reports of cases such as were used in this inquiry. Therefore it is not a matter of surprise that the author fails to give a good definition of the two kinds of deafness.

Notwithstanding this uncertainty of definition, the results as to the relative frequency of deafness in children of congenitally deaf parents and parents adventitiously deaf are decidedly interesting. Thus it is found that where both parents are congenitally deaf the percentage of deaf children is 25.931; where one parent is congenitally deaf and the other adventitiously deaf it is 6.538; while where both parents are adventitiously deaf it is but 2.326. But where one parent is congenitally deaf and the other hearing 11.932 per cent of the children

are deaf; and when one parent is adventitiously deaf and the other hearing the percentage is 2.244. Here appears again the surprisingly large number of deaf children of hearing parents. But it is very evident that adventitious deafness is transmitted much less readily than congenital deafness. Indeed, it cannot be proven by these statistics that the former is ever inherited, because of the unknown error in the classification of the two varieties of deafness.

The statistics show that the presence of deafness among the relatives of the parents increases very largely the chances that deaf children will be produced, and this is, of course, what would be expected. Taking the cases where both parents have deaf relatives (not including descendants), the percentage of deaf children where both parents are congenitally deaf is raised to 30.303; where both parents are deaf but only one congenitally deaf the percentage is 10.903; where one parent was congenitally deaf and the other hearing there is again a large percentage, 24.286; and where both partners are adventitiously deaf there are 9.649 per cent of deaf children. Now, taking the cases where only one parent had deaf relatives, the percentages are 20.0, 5.536, 11.864, and 2.801, respectively. Finally, where neither partner had deaf relatives the figures are 4.167, 1.515, 15.789, and 0.364. In this last series the first and third percentages represent one child and three children, respectively, and the third one would be much reduced if one doubtful case were discarded.

Over 45 per cent of the hearing parents whose family history is recorded had deaf relatives, while this is true of only about 32 per cent of the adventitiously deaf. This fact, taken in connection with the evidence as to the effect of history of deafness in the family of the parents in increasing the chances of deafness in the children, seems to explain to a great extent the large proportion of deaf children of hearing parents compared with those of the adventitiously deaf which appears in the general statistics. But even when the factor of family history is taken into account, as in the tables summarized in the preceding paragraph, there is still to be found a remarkably large proportion of deaf children of hearing parents. The author attempts to explain this on the ground of consanguinity. When both partners are deaf the largest percentage of deaf children is obtained from consanguineous marriages, 32.258 per cent; and in consanguineous marriages where one partner is deaf and the other hearing the percentage is nearly as large, 29.851. In cases of deafness, then, the peculiarity of the parents seems to be more strongly

inherited when they have a common ancestry. Now it is found that of the 3242 marriages where both partners were deaf only 12, or 0.370 per cent, were consanguineous; while of the 894 marriages where one partner was deaf and the other hearing 18, or 2.013 per cent, belonged to this class. The 20 deaf children born from the latter class of consanguineous marriages constitute 13.2 per cent of the total 151 deaf children born from marriages in which one of the partners was a hearing person; while the 10 deaf children from the former class of marriages constitute only 2.3 per cent of the total 429 deaf children having both parents deaf. It is difficult to see why consanguinity should so intensify hereditary characteristics; but if it does do so, then this large proportion of consanguineous marriages between the hearing and the deaf accounts to some extent for the large proportion of deaf children. How far this goes to explain the facts can only be determined mathematically; and this the author does not attempt.

It is to be regretted that the author did not inquire more particularly in regard to the condition of the parents of the deaf married persons. The parents were simply included in the general inquiry concerning "other relatives," with the result that on examining the Tabular Statement of Marriages one is disappointed to find that it is often impossible to tell whether the parents were hearing or unreported. If this point had been attended to, these statistics might have been expected to furnish an important confirmation, or the reverse, of Galton's law of filial regression.

R. P. B.

Blatchley's "Gleanings from Nature." — Mr. Willis S. Blatchley, State Geologist of Indiana, has published in book form, under the head of *Gleanings from Nature*, a number of fragments of popular science contributed by him to the press of Indiana and to Appleton's *Popular Science Monthly*.

The essays are truthful rather than literary, and they give vivid touches of nature, the results of close and sympathetic observation.

The first essay discusses charmingly the harbingers of spring in Indiana — the maples, skunk cabbage, trillium, yellow-hammer, fox sparrow, and the birds and flowers that mark the end of winter. Other topics discussed are "Two Fops among the Fishes," "Snakes," "The Gnat Catcher," "The Old Canal," "The Iron Weed," "The Indiana Caves and their Inhabitants," "The Tamarack Swamp," "The Katydid," "The Winter Birds," and "How Animals and Plants spend the Winter."

The volume is well printed by the Nature Publishing Company, and very well illustrated, in part with original photographs.

This book can be highly commended for its honesty and directness of purpose. Its author stands on his own feet and neither poses nor gushes, and his work is worthy of its purpose.

D. S. J.

ZOÖLOGY.

Artificial Production of Rhythmic Muscle Contractions.—

Professor Loeb¹ has pointed out that certain solutions containing ions of sodium, chlorine, lithium, bromine, iodine, etc., may cause rhythmical contractions in muscle, and that solutions containing certain other ions, calcium, potassium, magnesium, barium, strontium, etc., check such contractions. It is supposed that the rhythmic contractions are the result of the combination of the particular ions with the muscle. The rhythmic action of the heart may be a natural example of this kind of action.

G. H. P.

Evermann and Marsh on Fishes of Puerto Rico.—In the *Report of the United States Fish Commission* for 1899, Dr. Barton W. Evermann and Willard C. Marsh give an account of new species discovered by them in the late cruise of the *Fish Hawk* about the island of Puerto Rico under Dr. Evermann's direction. An elaborate account of these important investigations is in preparation. The present paper gives a preliminary account of three new genera of Blenniidae—*Gillias*, allied to *Tripterygion*; *Auchenistius*, a Blenny, allied to *Auchenopterus*; and *Coralliozetus*, allied to *Ophioblennius*—and of twenty new species belonging to different families. These are: *Lycodontis jordani*, *Stolephorus gilberti*, *Stolephorus garmani*, *Prionodes baldwini*, *Calamus kendalli*, *Doratonotus decoris*, *Sicydium caguaita*, *Gobius bayamonensis*, *Bollmannia boqueronensis*, *Microgobius meeki*, *Gillias jordani*, *Malacoctenus culebræ*, *Malacoctenus moorei*, *Malacoctenus puertoricensis*, *Auchenistius stahli*, *Auchenopterus albicaudus*, *Auchenopterus rubescens*, *Auchenopterus cingulatus*, *Auchenopterus fajardo*, and *Coralliozetus cardonæ*. Most of these are small fishes of

¹ Loeb, J. Ueber Ionen welche rhythmische Zuckungen der Skelettmuskeln hervorrufen, *Festschrift zum 70. Geburtstage des Herrn Geheimrath Prof. Dr. A. Fick*, pp. 101-119. 1899.

the coral reefs and rock pools, localities in which the greater number of the yet unknown fishes of the tropics are likely to be found.

Evermann and Marsh are to be congratulated on the use of the correct name of the island of Puerto Rico, instead of the lazy corruption of Porto Rico. This is, we believe, the first government document of the United States in which the name is correctly spelled. The spelling Puerto Rico is, however, now officially adopted by the Government Board of Geographical Names.

D. S. J.

Tunicates of Pribilof Islands.—Part III of "The Fur Seals and Fur-Seal Islands of the North Pacific Ocean," published by the Government, contains an account by W. E. Ritter of the Tunicates of Pribilof. Eleven species are reported upon, ten of which are new to science.

Physiology of the Cephalopods.—An excellent résumé of our knowledge of the physiology of the cephalopods has been given by Victor Willem in the *Bulletin Scientifique de la France et de la Belgique*, Tome xxxi, pp. 31-54. The article is accompanied by an extensive bibliography.

Excretion in Mollusca.—Cuénot¹ has studied the function of excretion in mollusks by means of physiological injections, and attains results which modify some generally accepted views derived from anatomical and histological data. From the review of the literature on Mollusca one sees that the excretory function has been ascribed primarily to the nephridia (organs of Bojanus), then also to the pericardial glands of lamellibranchs, and finally without sufficient proof to the modified pericardial epithelium and to certain scattered liver cells.

The interior of any animal maintains a relatively constant composition, due to the presence of excretory cells which remove any excess of normal material or any abnormal, *i.e.*, excretory, substance which would poison the organism. The cell exercises, however, the choice among such substances, thus demonstrating the varied nature of the excretory cells. Introduced substances may (1) enter into the cycle of metabolic changes; (2) be attracted and precipitated in skeletal or yolk material; (3) undecomposed and unfixed, be collected by excretory cells, and thus impart color to the excretory organs. Certain

¹ Cuénot, L. L'excrétion chez les Mollusques, *Arch. de Biol.*, vol. xvi (1899), pp. 49-96, Pls. V, VI.

cells absorb some substances with avidity, but are totally indifferent to others.

Among the variable types of excretory cells two appear to be constant; the first absorbs indigo-carmin and refuses ammonium-carminate, while the second precisely reverses this action. Rarely excretory cells do both, but even then the one more freely than the other. These two types are associated with voluminous organs. The indigo kidneys produce urea, uric acid, and urates, while in carminate kidneys, thus far known, none of these substances are formed, though some non-indigo excretory cells contain urates. A tabular view of such organs for various groups of animals is reproduced on the opposite page, together with the products of each organ so far as known.

After discussion of the special technique employed, the author lists the various names by which the connective-tissue cells of mollusks are designated by different investigators, and distinguishes at least two types of such cells: (*a*) Reserve cells enclosing glycogen, and (*b*) excretory cells. In the terrestrial pulmonate gastropods the two functions are associated in a single cell, as in the liver cells of vertebrates.

In two groups of mollusks the nephridia, instead of being lined throughout their entire extent by a single type of excretory cell, present noteworthy differences: in Amphineura the reno-pericardial ducts of acid reaction eliminate actively carminate and litmus, while the rest of the nephridium, formed of different cells, and with alkaline reaction, eliminates indigo. In prosobranch gastropods the nephridia present a series of anatomical and physiological differentiations: *Patella* has two nephridia, very different in size but both eliminating equally indigo; in *Trochus* and *Haliotis* the larger right nephridium absorbs indigo alone; the left nephridium, very different in structure from the other, becomes faintly colored by carminate; finally, in monotocardic prosobranchs the single nephridium possesses two sorts of cells. The most numerous, non-ciliate, eliminate indigo; the others, ciliated, eliminate only carminate—the single nephridium being thus a physiological equivalent of the two nephridia in the Diotocardia (*Trochus*, etc.).

In the Amphineura, Solenoconcha, and Gastropoda there are, in the connective tissue, numbers of cells acid in reaction, of which the vacuoles actively absorb carminate and litmus. These scattered cells correspond physiologically to the pericardial glands of lamellibranchs and to the branchial heart of cephalopods which have the same power.

MIXED KIDNEY (INDIGO AND CARMINATE).

Vertebrates (Mammals, Bufo, etc.)	Convolute tubules of kidney (alkaline)	Urea, uric acid, hippuric acid, etc.
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INDIGO KIDNEYS.

Tunicata (Phallusia, Molgula)	Closed kidney or blind vesicles	Uric acid
Sipunculida (<i>Phascolion strombi</i>)	Nephridium (acid)	Urate
Pulmonate gastropods (Oscanius)	Nephridium (acid)	Uric acid
Lamellibranchs	Nephridia (acid)	Urea, etc. Uric acid in Lutraria
Cephalopods	Nephridia	Uric acid in <i>Sepia</i> and <i>Octopus macropus</i> , Gua- nine or Xanthine in <i>O. vulgaris</i>
Crustacea decapoda	Labyrinth of antennal kidney and often vesi- cle (alkaline)	Leucomaine?
Chilopoda (Lithobius, Scolopendra, Geophi- lus)	Malpighian tubes	Urates and uric acid
Diplopoda (Iulus)	Malpighian tubes	Sodic urate and calcic ox- alate
Insecta	Malpighian tubes (alka- line)	Very often urates and uric acid

CARMINATE KIDNEYS.

Lamellibranchs (Pecten, Cardium)	Pericardial gland (acid)	Hippuric acid and sodic hippurate
Hirudinea	Convolute portion of nephridia	Leucomaine?
Crustacea decapoda	Vesicle of antennal kid- ney and branchial kid- neys (acid)	Carcinuric acid
Scorpions	Liver	Guanin

The pericardial glands of lamellibranchs manifest three different types: intra-auricular masses in *Pecten* and *Ostrea*, external epithelium of the auricles (*Mytilus*), tubular glands opening virtually into the pericardium (*Naiades*). *Pecten maximus* affords a clear transition from the type of the lamellibranchs to that of the gastropods in that the connective tissue encloses, as in the latter, many isolated cells, which are massed in the wall of the auricles. The products in the cells of the pericardial glands of either type are engulfed by phagocytes, which transport them into lacunæ of the circulatory system. Some of these phagocytes reach the exterior through the branchial membrane; the others become fixed for life in the connective tissue.

In the cephalopods the excretory connective-tissue cells are accumulated exclusively in the wall of the branchial heart and of the appendix to that organ. In both organs, however, cells of a different character are present. In various gastropods (*Pulmonata*, *Opisthobranchiata*, and some *Prosobranchiata*, as *Cyclostoma*) the liver contains numbers of excretory cells which discharge their products into the intestine.

The collaboration of closed excretory cells and phagocytes to eliminate waste products, or at least to localize them in indifferent regions, is found in many groups: *Oligochæta*, *Polychæta*, *Hirudinea*, *Sipunculida*, *Echinoderma*. This method of excretion, which encumbers the tissue with masses of solid granules increasing with age, is evidently an imperfect function, and not improbably contributes to determine the death of the individual.

HENRY B. WARD.

The Heart of Anodonta.—The action of the heart of *Anodonta* has been fully studied by V. Willem.¹ Under ordinary circumstances the heart beats four to six times per minute. Contraction can be induced in an empty, quiet heart by injecting fluid into it, but an overfilling of the heart will retard the rate of contraction. The contraction of the ventricle drives the blood out under a pressure of one to three and a half centimeters of water. When the ventricle contracts, the auricles expand, and together these organs always fill the whole pericardial space. The contraction of the ventricle acts as a suction pump on the blood in the gills, drawing it into the auricles, and as a force pump on the blood in the arteries.

G. H. P.

¹ Willem, V. *Recherches expérimentales sur la circulation sanguine chez l'Anadonte*, *Mém. couron. Acad. Roy. des Sciences, des Lettres, et des Beaux-Arts de Belgique*, tome lvii, 28 pp., 2 pls., 1899.

Grafting and Regeneration in Hydromedusæ.—An interesting series of experiments on grafting and regeneration of Hydromedusæ has been carried out by C. W. Hargitt.¹ Small pieces of vigorous hydroid stems were held together in different positions by slivers of lead and were thus readily grafted. The bells of *Gonionemus* were emarginated so as to check their spontaneous movements and were then held together in pairs in various positions by being strung on bristles. As a result of these experiments, it was found that pieces of hydroid stems united with one another with great freedom either orally or aborally, and thus gave evidence of no polarity. The success of the experiments was quite independent of the sexes of the individuals from which the parts came. While pieces from closely allied species could be intergrafted, material representing different genera did not respond successfully. The experiments on the medusæ showed that though these animals regenerated and grafted freely, aboral grafts were never successful, the animal thereby showing a marked polarity.

G. H. P.

Regeneration in Grafted Tissue.—As is well known, the tail of one species of tadpole may be grafted on the body of another, and the two parts in time form an effective union. If the two species used have characteristically different kinds of pigment, the fate of the tissues thus brought together can be easily followed. The grafted ectoderm eventually covers only the tip of the developing tail, whereas the grafted mesoderm forms a considerable part of that organ, *i.e.*, at the beginning of grafting, the grafted tissues are separated from the stock tissues by a single transverse plane; later the plane of separation between grafted ectoderm and stock ectoderm is much posterior to that between the two kinds of mesoderm. Grafted tails when cut off regenerate, and the results of this process have been studied by T. H. Morgan.² If cut transversely, the cut surface from which regeneration will take place may exhibit a face of ectoderm from the stock and of mesoderm from the graft. The grafted tail may be cut obliquely, so that the cut surface will exhibit stock and graft ectoderm and graft mesoderm. In all these cases the regenerated tails are composed of cells easily referable to their sources, and it may be concluded that in regeneration from a region

¹ Hargitt, C. W. Experimental Studies upon Hydromedusæ, *Biological Bulletin*, vol. i, No. 1, pp. 37-51. October, 1899.

² Morgan, T. H. Regeneration of Tissue Composed of Parts of Two Species, *Biological Bulletin*, vol. i, No. 1, pp. 7-14. October, 1899.

where the cells have been derived from two different species, the specific characters of the cells remain distinct.

G. H. P.

Note.—No. 3 of Vol. XV of the *Journal of Morphology* contains: "Studies on the Maturation, Fertilization, and Cleavage of *Thalassema* and *Zirphæa*," by B. B. Griffin; "On the Blood-Plates of the Human Blood, with Notes on the Erythrocytes of *Amphiuma* and *Necturus*," by G. Eisen; "The Phosphorescent Organs in the Toad-fish, *Porichthys notatus* Girard," by C. W. Green; "On the Species *Clinostomum heterostomum*," by W. G. MacCallum; and "Mitosis in *Noctiluca miliaris* and its Bearing on the Nuclear Relations of the Protozoa and Metazoa," by G. N. Calkins.

GEOLOGY.

The Absaroka Range of the Rocky Mountains.—In a presidential address before the Geological Society of Washington,¹ and in the Absaroka Folio of the United States Geological Survey,² Mr. Arnold Hague has presented the results of many years' field work in a region that contains for vulcanologists problems of extraordinary interest. The Absaroka Range forms the mountain barrier to the east of the Yellowstone plateau, and is composed chiefly of horizontally stratified volcanic flows and breccias thrown out from vents, the location of which is not marked by conical volcanoes or even by any positive trace which would show that such volcanoes existed. Thicknesses from two thousand to five thousand feet of these lavas are deeply trenched by streams draining the eastern face of a range which marks in a sense the eastern escarpment of the great plateau that forms the Yellowstone Park. Early breccia and basalt sheets overlaid by late breccias and basalts make up the mass of these lavas. The only interruptions to their horizontal continuity are massive bodies of intrusive rock that invaded the lavas at two distinct periods.

Evidence of the age of the lavas is derived from the contained plant remains and from the old topographies which underlie them. The accumulation of volcanic material rests unconformably on rocks

¹ Hague, Arnold. Early Tertiary Volcanoes of the Absaroka Range.

² Folio No. 52, *Geologic Atlas of the United States*, Crandall and Ishawooa Quadrangles. Washington, 1899.

ranging from archæan to cretaceous, and is confined within ancient orogenic barriers on the north and south. Evidence of erosion during the piling up of the eruptive material is shown by canyon cross-sections, which give evidence of old depressions filled with silts and gravels; this indicates that considerable erosion took place at different times, with long interruptions in the local volcanic activity. Over one hundred and fifty species of plants have been identified from the tuffs and breccias, indicating a range in age from eocene to upper miocene. They are thus geologically older than the neocene rhyolites that form the greater portion of the Yellowstone Park.

The intrusive bodies occur as stocks and dikes; an earlier group, the "Sunlight" intrusives, is characterized by orthoclase and augite, and cuts the earlier breccias and basalts. The "Ishawooa" intrusives have broken into the later basalts as well as the earlier and are more siliceous rocks, ranging from diorite and diorite porphyry to true granitic types. Dikes are associated with all the larger bodies, sometimes being offshoots from them, in other cases cutting them or cut by them, and presenting a marvelous variety of structural and lithological types that afford material for the study of extensive gradation between coarse crystalline and glassy volcanic rocks. Many of the dikes of the Sunlight group are orthoclase basalts, collectively called by the name "absarokite," and are related to coarser monzonite stocks, which range in composition from quartzose augite syenites to coarse gabbros and diorites. These older intrusive bodies occur in three principal masses that form the points of a triangle, and about two of them the dikes show remarkable radiation. The Ishawooa intrusives extend for a distance of fifty miles into the Yellowstone Park, occurring as stocks, sheets, and dikes; they are usually conspicuous about the head waters of the eastern flowing streams, but do not form culminating summits, these being usually composed of the breccias or late basalts which overlie the intrusive rock. Dikes here, too, are abundant, but radiation is not especially marked, the greater masses having rather an axial trend in a northwesterly direction, as though injected through a common fissure, rather than as forming independent intrusions. The breccias in contact with the greater intrusive bodies are indurated to a distance sometimes of more than one-half mile. Coarse granites and diorites occur in both the intrusive series—a remarkable fact when we consider that the lavas invaded by them are of Tertiary age.

Mr. Hague concludes that variation in coarseness of crystallization is not dependent upon pressure, but is far more affected by the rate of cooling. He agrees with Professor Iddings in the belief that, for the same stock and its complex of dikes, variations in composition and structure are due to varying conditions of crystallization from a single molten magma. Hague, however, differs from Iddings in his conception of the significance of the apparent radiation of dikes about the diorite and monzonite stocks of the Crandall quadrangle; Iddings believes this radiation to indicate that the central mass represented the root of a great conical volcano now eroded away, which he reconstructed to a height of ten thousand feet above the plateau at its present level. Mr. Hague fails to find any evidence of the building up of great volcanic piles, but compares the region to Iceland, where there are many centers of eruption and fissures through which the lava breaks forth, old sources of eruption in time becoming obliterated by fresh flows from newer vents.

The geologic maps of the Absaroka Folio show in very striking fashion the horizontal character of the flows and breccias where the digitate drainage intersects adjacent formations. The most conspicuous features shown by the map are the regular trend of the main divide on the southwest, parallel to the Ishawooa intrusive bodies, and the wonderful abruptness of the eastern gorges in contrast with the gentle slope of the streams which flow down to the high basin of Yellowstone Lake on the west. A conspicuous feature of the physiography is the remarkable curve from west to east of the head of North Fork Stinkingwater River, its head-water trend conforming exactly to the trend of Sunlight Creek, across the high divide formed by intrusive bodies in the Sunlight mining region. The Absaroka folio is illustrated by reproductions from photographs showing the deep canyon of Clark Fork cut in archæan granite, Index Peak composed of breccias overlying palæozoic limestone above archæan rocks, other pictures of dikes and breccias, and a view of Sunlight Glacier, one of the small remnants of the great glaciers that formerly played an important part in the erosion of the plateau.

The geological history of the region is briefly as follows. Palæozoic and mesozoic sediments were deposited throughout a long period to a thickness of many thousand feet, and at the close of Laramie time, mountain-building took place, producing uplift and deformation that was contemporaneous in all the ranges of the northern Rocky Mountains. This post-Laramie movement produced

mountain ranges and plateaus which were considerably eroded before the first volcanic eruptions. These eruptions throughout Tertiary time are conceived to have had their manifestation by a variety of processes, in part building up volcanic cones, in part ejecting fluid lavas through fissures, and in part hurling out from vents which have left but few traces enormous masses of brecciated volcanic rock in a fashion that is without parallel in any region of active volcanoes. This great accumulation of surface lavas was later invaded by igneous magmas believed to be the elevated portions of a great complex of deep-seated crystalline rock; "where the underlying molten magma was subject to the severest pressure, the material was squeezed upward to higher levels following lines of least resistance, and consolidated at greater or less depths beneath the surface. . . . The line of Ishawooa intrusives marks the trend of one such upward movement of molten magma, which for the most part congealed without finding egress to the surface."

The two most remarkable features of Mr. Hague's observations in the Absaroka volcanic district are the enormous mass of breccias and the Tertiary granites and diorites. The explanation of the origin of the former as from divers vents along fissures and the demonstration of the coarsely crystalline character of the intrusive stocks add new evidence to dispel the time-honored but erroneous notion that great cones like *Ætna* or *Vesuvius* are essential features of great volcanic activity, and that granite is necessarily a very ancient rock. The Tarawera eruption of New Zealand and the fissure eruptions of Iceland show that the cone is an incidental product of eruption, not an essential. Geikie has brought forward, in his *Ancient Volcanoes of Great Britain*, much evidence to show that similar fissure eruptions were the prevailing type that produced the Tertiary basalt plateaus, and he too describes coarse granitic rocks of Tertiary age. The chief point of difference in the Absaroka Range is in the *brecciated* character of the horizontal lavas; the brecciated fragments are of all shapes and sizes and of great variation in kind, but nearly always volcanic. How did these breccias first crystallize as andesites or basalts in what were presumably continuous bodies of some sort, and later become broken up? This is a problem that has long puzzled the Yellowstone geologists, and for its complete solution an extended study and comparison of similar tuffs and breccias throughout the Cordilleran district will probably be required.

T. A. JAGGAR, JR.

PETROGRAPHY.

Experimental Petrography. — With the increasing number of experiments being made in the attempt to discover the laws governing the formation of crystalline rocks from their magmas some important truths should soon be disclosed. The latest contribution to the subject has recently been made by Bauer,¹ who worked along conventional lines. He fused powdered rocks, mixtures of powdered minerals, and mixtures of chemical compounds, with and without the addition of "mineralizers," held them at temperatures of 1000°–1400° for ten or more hours, and then allowed them to cool. Unfortunately he was unable to prolong the cooling stage to any great extent, and consequently the products obtained were largely glassy.

The wolframates, boric acid, and borax served well as "crystal-lizers." Under the influence of the first, quartz was produced, and with the aid of the other two, hornblende. The addition of the chlorides and fluorides to the mixture appeared to serve simply to lower the fusing point.

The quartz was obtained as irregular grains in a mass composed of a groundmass of glass, enclosing small laths of feldspar and larger crystals of orthoclase, albite, olivine, and nepheline. This was produced by fusing a mixture of orthoclase, albite, mica, hornblende, sodium chloride, potassium tungstate, boric acid, and sodium phosphate. The quartz is thought to have originated in the breaking up of the mica.

The hornblende was obtained in three experiments. The most interesting consisted in the fusion of a mixture of powdered phonolite and nepheline-basalt, neither of which contained any trace of the mineral. The hornblende was a bright-green variety. In one of the other two experiments powdered diorite was fused with boric acid, sodium phosphate, and calcium fluoride at a temperature of 1000°. The resulting hornblende was brown, while that in the original diorite was green.

The third experiment yielded also brown hornblende. In this powdered hornblende was fused with sodium and calcium fluorides and magnesium chloride.

Another interesting result reached was the discovery that the same mixture under different conditions of temperature and rates of cooling may yield entirely different products. For instance, the powder

¹ Bauer, K. *Neues Jahrb. f. Min.*, etc., Bd. xii, p. 535.

of a nepheline-basalt gave in one case a nepheline-basalt and in two other cases limburgites.

In order that the best results may be reached the author declares that specially prepared apparatus is necessary, but with a proper equipment he believes that much might be learned concerning the method of origin of the different types of igneous rocks by simple fusion experiments.

Notes. — The dikes cutting the mica-gneisses in the vicinity of Johns Bay, Maine, are similar in all essential respects to those near Portland in the same state. Miss Bascom¹ reports that two are olivine diabases, and a third is nonolivinitic.

Gratacap issues a plea² for a more interesting display of rocks in museums than that one usually sees. He also suggests along what lines such a display might be constructed to be at the same time of interest and of value.

Judd³ describes under the name of rockallite the peculiar rock of Rockall Island in the Atlantic, 240 miles west of Ireland. The rock consists of ægirite, quartz, and albite in the proportions 39 : 38 : 23. The albite is sometimes porphyritic. An analysis gives :

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	NiO	MgO	CaO	K ₂ O	P ₂ O ₅	Total
73.60	4.70	13.10	93	.06	.11	.37	6.96	=	99.83

The structure is granitic. Its systematic place is in the granite group, although its feldspar is solely albite.

The rocks gathered by the International Boundary Commission along the newly surveyed boundary line between the United States and Mexico are granites, gabbro-diorites, diabases, diorite, porphyries, rhyolites, andesites, and basalts.⁴ One of the rhyolites is spherulitic.

The collection of rocks made by Alexander Agassiz in the Fiji Islands contains specimens of granite, andesites, and basalts. Eakle⁵ describes augite-andesite as the predominant rock of the islands. It varies from a very feldspathic type to a very basic type that appears to grade into basalt. In addition to this andesite there are also present hypersthénic and hornbléndic varieties.

¹ *Amer. Geol.* (1899), vol. xxiii, p. 275.

² *Ibid.*, p. 281.

³ *Trans. Roy. Irish Acad.*, vol. xxxi, Pt. iii, p. 39.

⁴ Lord, E. C. E. *Proc. U. S. Nat. Mus.*, vol. xxi, 1899, p. 773.

⁵ *Proc. Amer. Acad. Arts and Sci.*, vol. xxxiv (1899), p. 581.

Cole¹ suggests an approximately quantitative method for determining potassium in the constituents of igneous rocks. It is a blow-pipe method differing from Szabo's in that the assay is fused in a bead of sodium carbonate. The advantages of fusing with sodium carbonate in place of the gypsum used in the Szabo method are : (1) The certainty of differentiating the potassium from the sodium flame ; (2) complete decomposition of the assay ; (3) security against loss of the assay ; (4) convenience.

¹ *Geol. Mag.*, March, 1898, p. 103.

PUBLICATIONS RECEIVED.

(The regular exchanges of the *American Naturalist* are not included.)

CORY, CHARLES B. The Birds of Eastern North America known to occur east of the ninetieth meridian. Part II, Land Birds. Chicago, 1899.

DILLER, J. S. The Coos Bay Coal Field, Oregon. Washington, 1899.

ELLIOT, D. S. List of Mammals obtained by Thaddeus Surber, Collector for the Museum chiefly in Oklahoma and Indian Territories. *Field Columbian Museum, Publication 40*, 1899.

FRY, EDWARD, and FRY, AGNES. The Mycetozoa and some questions which they suggest. London, "Knowledge" Office, 1899. 8, 82 pp.

GOTO, SEITARO. Notes on some exotic species of Ectoparasitic Trematodes. *Journ. Sci. Coll. Imper. Univ. Tokyo*. Vol. xii, Part IV, 1899.

KING, F. H. Irrigation and Drainage, Principles and Practice of their Cultural Phases. New York, The Macmillan Company, 1899. 21, 502 pp., 162 figs. \$1.50.

MEEK, S. E. Notes on a Collection of Fishes and Amphibians from Muskoka and Gull Lakes. *Field Columbian Museum, Publication 41*, 1899.

Australian Museum. Records. Vol. iii, No. 6, 1899. — *Geographical Journal.* Vol. xv, No. 1, January, 1900. — *Maryland Geological Survey.* Vol. iii. Baltimore, 1899, 461, 80 pp., 35 pls. — *Maryland Weather Service.* Vol. i. Baltimore, 1899. 566 pp., 54 pls. — *Natural Science Association of Staten Island. Proceedings.* Vol. vii, No. 12. Dec. 9, 1899. — *Revista Chilena de Historia Natural.* Ano iii, Nos. 10, 11, 1899. — *Science Gossip.* January, 1900. — *United States Commissioner of Education. Report for the year 1897-1898.* Vol. ii, Washington, 1899. 1281-2640 pp. — *United States Fish Commission. Bulletin.* Vol. xviii. Washington, 1899. 576 pp., 43 pls. — *Wyoming Experiment Station. Bulletin 41.* Index Bulletin B.

(Number 397 was mailed February 6.)